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ABSTRACT

The goal of this curriculum is to teach students to think about their daily habits and to make environmentally responsible choices. The lessons and activities are divided by grade levels: 6-8 and 9-12. Lessons in each grade level are designed to cover a range of student skills, subject areas, and environmental issues. An extensive resource section includes background information on specific issues at the state and global level as well as a glossary. Each lesson has a teacher's section which includes grade level, lesson focus, materials, teaching time, and vocabulary. Most lessons are interdisciplinary and include extension activities and ideas for individual and group action for environmental causes. Topics covered in the lessons include litter control, waste disposal, recycling, water pollution, and conservation of energy. (DDR)

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Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum Supplement

1996
Second Edition

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For more information on how to obtain a copy of
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contact the Office of Solid Waste Reduction and Recycling at
1-800-SO-USE-IT.



Action for a cleaner tomorrow is printed on recycled paper



State of South Carolina

DAVID M. BEASLEY
GOVERNOR

Office of the Governor

POST OFFICE BOX 11369
COLUMBIA 29211

FOREWORD

I am pleased to introduce *Action for a Cleaner Tomorrow: A South Carolina Environmental Curriculum*.

Action was developed by DHEC's Office of Solid Waste Reduction and Recycling in conjunction with a statewide team of teachers, the South Carolina Department of Education, Clemson University Extension Service and the state "Keep America Beautiful" affiliate.

The curriculum serves as an excellent example of what can be accomplished when various groups work together for a common goal. The first edition of the curriculum was introduced in 1994 and won two national education awards. *Action* has also received recognition from the United States Environmental Protection Agency's Region IV Office and is currently being adapted for use by other states. At home, response to the curriculum has been overwhelmingly positive, with more than 4,000 teachers having been trained to use *Action*.

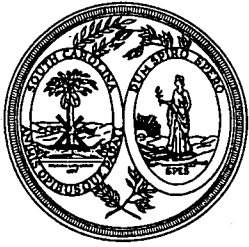
The second edition promises to be just as successful, with current lessons having been updated and new lessons having been added covering a range of additional environmental topics.

Environmental education is critical to maintaining the quality of our life. As we meet the challenge of protecting our environment and natural resources, the fact is there is no more precious natural resource than our children. This project is for them.

Action for a Cleaner Tomorrow and projects like it are the tools needed today to cultivate the environmentally conscious adults of tomorrow.

It is indeed my pleasure to introduce this curriculum for use in South Carolina classrooms.

A handwritten signature in cursive script, reading "David M. Beasley".
David M. Beasley



STATE OF SOUTH CAROLINA

DEPARTMENT OF EDUCATION

Dr. Barbara Stock Nielsen

STATE SUPERINTENDENT OF EDUCATION

Dear Teachers and Children of South Carolina,

The environment and quality environmental education are important to us and should be important to everyone. Only by prioritizing environmental education can we build a new environmental ethic and encourage responsible action. That is the ultimate benefit.

"Action for a cleaner tomorrow" is a curriculum designed by South Carolinians for South Carolinians. It is designed to give all of our students the knowledge, the information, and the skills to make informed and responsible decisions toward environmental problems that affect our beautiful state and our precious natural resources. This curriculum encourages investigation, analysis, and decision making about such environmental topics as solid waste management, recycling and the wise use of our resources.

We CAN make the difference and our students can become leaders of environmental consciousness. "Action for a cleaner tomorrow" will lead to a cleaner tomorrow and to a cleaner South Carolina.

Sincerely,

Barbara S. Nielsen
Barbara S. Nielsen, Ed.D.
State Superintendent of Education




UNITED STATES DEPARTMENT OF EDUCATION
THE SECRETARY

**FOREWORD FOR SOUTH CAROLINA
"ACTION FOR A CLEANER TOMORROW"
SOLID WASTE MANAGEMENT AND RECYCLING CURRICULUM
BY RICHARD W. RILEY**

From the glorious Appalachian mountains to the celebrated beaches of the Grand Strand and Lowcountry, South Carolina's natural resources are renowned worldwide. The beauty of our state contributes to a high quality of life for residents and attracts millions of visitors who boost our economy. It is critical that we protect our precious environment for ourselves and future generations.

With the adoption of the South Carolina Solid Waste Policy and Management Act of 1991, our state now has a comprehensive law to regulate the management of solid waste. One of its most important components requires a solid waste and recycling curriculum in our schools. "Action for a cleaner tomorrow," a curriculum developed specifically for South Carolina, is now a required course of study.

Experience has shown us that learning about the importance of protecting the environment and effective solid waste management can have a tremendous positive influence on the attitudes and habits of children and their parents. As conservation and recycling become customary, it is my hope that South Carolina's citizens will become her primary caretakers.


Richard W. Riley
U.S. Secretary of Education



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

FOREWORD

One of EPA's goals for environmental education is to reach every home, school, and community across the nation with a message of environmental stewardship and a balanced view of the environmental issues. The best way to achieve this is through the cooperative efforts of not only federal, state, and local governments, but also business, education, and community organizations. No one organization can accomplish this on its own.

Action for a cleaner tomorrow: A South Carolina Environmental Curriculum represents one way this message can be delivered effectively. I am impressed not only with the scope of the subject matter covered, but also the process with which it was developed ensuring the integrity and broadest possible application of the materials. It is encouraging to see statewide efforts such as these which involve the collaboration of a broad cross-section of state and local environmental and educational groups. These types of partnerships and alliances are critical in the development and delivery of environmental education.

The curriculum is interdisciplinary and includes both in-class and at-home activities that will help students *and* their parents see the impact of their everyday behavior on the environment. Children can influence their parents to recycle at home, while parents can influence their children to compost their food scraps and yard trimmings. Students can influence their teachers to start or improve a school-wide recycling program, while teachers can influence their students to pursue environmentally related careers.

I am confident that the introduction of this curriculum in schools throughout South Carolina will provide a much needed catalyst for quality environmental education and will promote responsible environmental stewardship. Stewardship means taking responsibility for, caring for, and managing the earth's natural resources. Individual actions can and do make a difference. As students complete the activities, they will be able to carry the message of stewardship beyond the school and into their homes and the larger community across South Carolina. Learning and applying the principles of solid waste management and recycling outlined in this curriculum will contribute greatly to conserving and protecting our environment.

Richard D. Nawyn, Chief
Environmental Education & Public Outreach

Environmental issues are neighborhood issues. As good neighbors, we should recognize that simply going through our daily routines affects the world around us ... and we must teach our children responsible environmental habits.

Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum Supplement

Action for a cleaner tomorrow, a South Carolina environmental curriculum, has been developed to teach the children of South Carolina ... and, ultimately, their parents ... to think about their daily habits and to make environmentally responsible choices. The name of this curriculum, **Action for a cleaner tomorrow**, is simply a reminder that practicing environmental responsibility is a matter of forever learning more about the world around us and taking action for a cleaner tomorrow.

This curriculum tries to reflect the environmental issues facing the world today with a particular emphasis on South Carolina's concerns and goals. By bringing the issues home ... to our state, community, and backyards ... the curriculum strives to show that we can make a difference. To provide a well-rounded study of South Carolina's environment, in addition to lessons on solid waste reduction and protecting our natural resources, this Second Edition of the curriculum supplement also includes activities on air and water quality, and energy.

The Curriculum Development Team consisted of representatives from the South Carolina Department of Health and Environmental Control's Office of Solid Waste Reduction and Recycling; a dedicated group of teachers representing all grade levels and subject matters, a cross section of both rural and urban areas, and public and private schools; representatives from the South Carolina Department of Education; and writing and design consultants, Haggard & White. The curriculum has been reviewed by and comments received from teacher pilot testing groups as well as various industry and environmental groups.

By receiving input from groups and individuals with varying experiences, the Curriculum Development Team strived to provide a broad informational base and a balanced view of environmental issues. And the issues are dynamic. As research continues and as technologies expand, the practices of waste disposal and environmental protection will change. *Action for a cleaner tomorrow* will be reviewed and revised as technologies and environmental issues evolve. We'd like to hear from you. We want to know what you and your students think, how you are using the lessons, what additional topics you would like covered, etc. To stay on our mailing list, return the comment sheet enclosed at the end of this curriculum.

Waste will be with us always. It's up to us ... and the next generations ... to develop and maintain responsible daily habits. We challenge today's teachers and students to take a stand and take "Action for a cleaner tomorrow."

Acknowledgements

Developing *Action for a cleaner tomorrow* has involved education, environmental, and communication experts from across South Carolina. The success of *Action for a cleaner tomorrow* is a result of the dedication and commitment of many people who care not only for the environment, but more importantly, for the children of South Carolina. The South Carolina Department of Health and Environmental Control's Office of Solid Waste Reduction and Recycling would like to acknowledge the efforts of these people for their assistance in preparing *Action for a cleaner tomorrow*, South Carolina's environmental curriculum.

Curriculum Development Team

Core Committee

Lorraine Conrad, Chair

Science/Health Coordinator, Richland School District 2

Audrey Andrieski, North Springs Elementary School

Pat Bartholomew, Springfield Elementary School

Marcia Burckhalter, Barnwell High School

Jana DeHoff, Saxe Gotha Elementary School

Jane Etta Dion, Pinewood Prep School

Karen Durand, J.B. Edwards Elementary School

Don Franklin, Wade Hampton High School

Pamela Hanfland, Conder Elementary School

Jane Hayes, Rock Hill Clean & Green

Brenda Keeling, Rawlinson Road Middle School

Fran Kirby, Batesburg-Leesville Elementary School

Jim Laughner, Porter Gaud School

Mary McConathy, Aiken County Public Schools

Linda Mobley, Richland Northeast High School

Renee Potts, Pendleton Junior High School

Shirley Trebil, Manning Elementary School

June Wise, W. E. Parker Elementary School

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Rebekah Baker, *Wood Elementary School*
Elizabeth Baldwin, *Summerville High School*
Charlene Brewer, *McKissick Elementary School*
Peggy Carey, *Hilton Head Primary School*
Diane Curlee, *Bowman Academy*
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Eva Gaddy, *St. Johns High School*
Cynthia Gardner, *Gilbert Elementary School*
Linda Horrell, *Walterboro High School*
Linda Hudson, *Clinton Elementary School*
Mary Ann Moody, *Lake View Elementary School*
Judy Moser, *Greenbriar Elementary School*
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Sara Ann Pope, *Wood Elementary School*
Linda Price, *League Middle School*
Lynnette Richardson, *Lake View Middle School*
Lorie Sabol, *Saxe Gotha Elementary School*
Lenette Sawyer, *St. Johns Elementary School*
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Kathy Timms, *Fairfield Middle School*
Gail Twisdale, *Hilton Head Primary School*
Joanne Walsh, *League Middle School*
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Carolyn Wimberly, *Guinyard Elementary School*

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Judy Baxley, <i>Williston-Elko Middle School</i>	Anne Halter, <i>Harbor View Elementary School</i>
Brenda Beasley, <i>Brewer Intermediate School</i>	Karen Harris-Sweetman, <i>Williston-Elko Middle School</i>
Donna Belk, <i>Kinard Elementary School</i>	
Tamara Bishop, <i>Fennell Elementary School</i>	Jeanne Hartley, <i>Lexington Middle School</i>
Martha Brailsford, <i>C.E. Williams Middle School</i>	Sharon Harvley, <i>Iva Elementary School</i>
Betty Broadhum, <i>James F. Byrnes Academy</i>	Patti Hinson, <i>Andrew Jackson Middle School</i>
Virginia Buchanan, <i>Westminster Christian School</i>	Ann Holland, <i>Oakwood-Windsor Elementary School</i>
Mae Charles Byars, <i>Jonesville Elementary School</i>	Lee Howell, <i>Jefferson Elementary School</i>
Kiersten Byrd, <i>Finley Road Elementary School</i>	Carolyn Hughes, <i>Woodruff Elementary School</i>
Willie Cain, <i>Blenheim Middle School</i>	Sheryl Jackson, <i>Angel Oak Elementary School</i>
Barbara Cely, <i>Allendale Elementary School</i>	Susan Jennings, <i>West Hardeeville Elementary School</i>
Melissa Chance, <i>Estill Elementary School</i>	Joyce Jordan-Smith, <i>Rainbow Kindergarten</i>
Linda Collins, <i>Bennettsville Elementary School</i>	Joyce Kale, <i>Bowman Elementary School</i>
Leslie Cope, <i>Carver Edisto Middle School</i>	Charlotte Karnes, <i>York Road Elementary School</i>
Michelle Corvino, <i>DuBose Middle School</i>	Carla Keasler, <i>Pendleton Junior High School</i>
Carole Cospers, <i>Fort Mill Elementary School</i>	Joyce Kimbrell, <i>Fort Mill Primary School</i>
Julia Cote, <i>Chester Middle School</i>	Emma Caroline Kinney, <i>Latta Middle School</i>
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Denise Davis, <i>Edwards Elementary School</i>	Maureen Kondracki, <i>St. Peter's Elementary School</i>
Terry Dennis, <i>Jackson Middle School</i>	Angie Lancaster, <i>Arcadia Elementary School</i>
Gerald Duvall, <i>Johnakin Middle School</i>	Patricia Lanning, <i>St. Mary's Elementary School</i>
Rhonda Ewing, <i>Stratford High School</i>	Princess Lipscomb, <i>Woodruff Primary School</i>
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Abraham Funchess, <i>John Ford Middle School</i>	Susan Massingill, <i>Calhoun Elementary School</i>
Angela Gibbons, <i>Manning Elementary School</i>	Carole McAfee, <i>West Pelzer Primary School</i>
Cathy Gilmore, <i>Leavelle McCampbell Middle School</i>	Mary McConathy, <i>Oakwood-Windsor Elementary School</i>
Linda Gordy, <i>North Augusta Middle School</i>	

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Beta Pilot Test Teachers, continued

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Marsha Moon, *Finley Road Elementary School*
Beatrice Morris, *Hopkins Elementary School*
Carolyn Murphy, *Sunmit Parkway Middle School*
Pamela Nichols, *DuBose Middle School*
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Kim Noe, *Pontiac Elementary School*
Kathy O'Conner, *New Prospect Elementary School*
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Susan Rowe, *Monroe Pinckney Middle School*
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Debbie Sessions, *Sanders Elementary School*

Julie Setzler, *Jennie Moore Elementary School*
Linnea Shick, *Ben Lippen School*
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Sandra Smith, *West Elementary School*
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Sharon Thomas, *Berkeley Elementary School*
Sandra Thompson, *Ebenezer Avenue
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Polli Vaughn, *Rawlinson Road Middle School*
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Donna Whitesides, *Ronald McNair Junior
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Laura P. Timmons, *Satchel Ford Elementary School*
Jodi Watjen, *Gaffney Senior High School*

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Thank You

Thank you to all the high school teachers from throughout South Carolina who participated in the pilot testing of the 9 - 12 lessons and activities. Taking these lessons into the classroom provided us with a wealth of information. The teachers listed here gave their time to attend the initial high school training sessions, to share several lessons with their students, and to provide comments.

Norma L. Ashburn, *Hanahan High School*
Jan Baker, *Pickens High School*
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Lynda Lamb, *Chapin High School*
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John McGill, *Westminster High School*
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Deborah Minick, *Saluda High School*
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The Office of Solid Waste Reduction and Recycling gratefully acknowledges the review and comments of Thom Berry, director, Division of Media Relations; Jan Tuten, public information director, Division of Media Relations; the staff of the Planning Section of the Division of Solid Waste Planning and Recycling, Art Braswell, manager. Additional thanks to the Dr. Fran Wolak, Clemson Extension Service and Keep America Beautiful.

Tom Biga, Saluda County
Chip Boiling, Charleston County
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Julia Cagle, KAB of the Midlands
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How To Use

Action for a cleaner tomorrow.

Action for a cleaner tomorrow lessons and activities are divided by grade levels K-1, 2-3, 4-5, 6-8, and 9-12. Lessons in each grade level are designed to cover a range of student skills, subject areas, and environmental issues. Most lessons are interdisciplinary. Teachers are encouraged to review all the lessons and choose the ones that best reflect their students' abilities and the local issues. An extensive **Resource** section covering background materials provides a great deal of information on specific issues from both global and South Carolina perspectives. In addition to the Resource section are a Glossary and lists of books and videos available through various agencies including DHEC's Office of Solid Waste Reduction and Recycling.

A Step Back to Go Ahead

It is important to note that, since *Action for a cleaner tomorrow* is the first environmental curriculum supplement produced specifically for South Carolina, some of the topics and information will be new to students. Therefore, it may be necessary for teachers to go back and choose lessons from an earlier grade level to establish a foundation for learning more advanced concepts. However, since this is a curriculum for grades K-12 and students will be progressing through the curriculum as they progress through their grades, please do not move forward and select lessons from higher grade levels.

For ease of use, lessons have been designed to follow a specific format. For convenience, each lesson begins on a right-hand page.

Understanding the Teacher's Box

On every lesson, teachers will find the Teacher's Box in the upper left-hand corner of the first page of the lesson. In this box you will find:

- the appropriate **Grade** level
- **Focus** of the lesson
- **Subject** matter
- **Materials** - Materials listed in this box are for the primary teaching activity and may not be the materials needed for Extension Activities.
- approximate **Teaching Time**
- suggested **Vocabulary** - You will find these definitions in the Glossary.

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Additionally, under the title of each lesson is an indicator of the level of teacher preparation for the lesson; **Easy-To-Do**, **Moderate**, or **Extensive**. This attempts to indicate *teacher preparation time and not the level of difficulty or the amount of classroom or research time for the students*. For example, an Easy-To-Do lesson may take only a few minutes of a teacher's time to prepare, but may take students several days to complete.

Understanding the Lesson Format

Lessons follow a format that lists:

- **Learning Objective** - This is a statement indicating what students should learn.
- **Background** - The Background information may be supplemented with information from the Resource section. This information is intended for the teacher to share with their students in language appropriate for their understanding.
- **expanded Materials list** - For lessons requiring an extensive list of materials, the Materials listing in the Teacher's Box will direct teachers to this list located in the text of the lesson.
- **Learning Procedure** - A step-by-step outline of the procedures for meeting the Learning Objective. Teachers will certainly want to adapt these procedures for their class and available resources. The Learning Procedure serves as a guide and is not intended to be a script.
- **Questions for the Class** - These may be leading questions and appear before the Learning Procedure to generate interest or they may be summary questions at the end of an activity. While not all lessons have suggested Questions for the Class, teachers will want to develop their own questions to meet the needs of their students.
- **Extension Activities** - These activities point to further exploration of the topic area. They may include independent student research or additional classroom projects. Note: the materials required for Extension Activities are not included in the list of materials in the Teacher Box at the beginning of each lesson.
- **Down To Earth** - While the curriculum focuses on the United States and South Carolina in particular, Down To Earth offers a global environmental perspective. This information covers a variety of general environmental topics not necessarily tied to the focus of the lesson. It is intended as an informational nugget for the teacher to share with students as appropriate.
- **Just Do It** - Just Do It suggests an action that students as individuals can perform at home with family or friends to make a difference.

x

Please note: this format is a guide. In some instances the format has been modified to fit the educational objectives. In other words, substance supersedes format.

In many cases, questions are posed for the students' consideration. Where appropriate, suggested answers have been provided and appear in italics immediately following the question. You will find pages to copy for student worksheets and handouts as well as pages that can be made into transparencies for overheads, etc.

Action for a cleaner tomorrow is action packed.

This is an activity-based curriculum. Lessons encourage teachers and students to roll up their sleeves and make a difference. Whether you are building a compost pile, digging through the trash, making acid rain, or making recycled paper, you will find these lessons are hands-on activities that make students think for themselves ... to get their own facts ... to form opinions ... to make decisions ... and to take action.

This curriculum should serve as a starting place for incorporating basic environmental education in your classroom, or for challenging students to learn more ... about their state, and the state of their environment.

BEST COPY AVAILABLE

Lesson title and estimate of teacher preparation time.

Teacher's Box offers, at a glance, the Grade Level, Focus, Subject, Materials, Teaching Time, and Vocabulary

Learning Objective is a brief statement that indicates what students should learn.

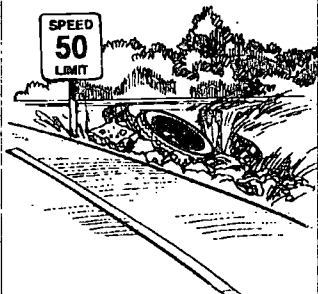
The Background information may be supplemented with information from the Resource section. This information is intended for the teacher to share with students in language appropriate for their understanding.

211 F

Taking Trash Where?

Preparation Time: 10-15 min Moderate 10-15 min

Grade: 2-3
Focus: Trash disposal
Subject: Social Studies, Language Arts, Science, Art
Materials: Large roll of butcher paper, crayons, markers, glue, scissors, magazines (optional)
Teaching Time: Three class periods
Vocabulary: Trash, garbage, trash hauler, sanitary landfill, open dump




Learning Objective
 Students will:

- recognize the importance of taking trash away
- learn where their trash goes.

Background
 For more information on different disposal methods in South Carolina, see the Resource section.

Many students know that household garbage is either picked up from their homes by **trash haulers** each week or their parents take it to the local roadside containers, sometimes called "greenboxes." **Garbage** is the name generally used for household solid waste. **Trash** consists of material considered worthless, unnecessary, or offensive that is usually thrown away.

Once garbage and trash was taken to large open dumps. Open dumps are a waste management strategy of the past. Open dumps have been replaced by state-permitted sanitary landfills operated by trained technicians who use bulldozers to compact each day's trash and cover it with a layer of dirt. The dirt helps control rodents and odors, and prevents fires.



The countries that produce the most municipal solid waste per capita are Australia, New Zealand, France, Canada and the United States.

Source: 1993 Environmental Almanac 22
 FACB 15

While the curriculum focuses on the United States and South Carolina in particular, **Down To Earth** offers a global environmental perspective. This information covers a variety of general environmental topics not necessarily tied to the focus of the lesson. It is intended as an informational nugget for the teacher to share with students as appropriate.

Learning Procedure
A step-by-step outline of the procedures for meeting the Learning Objective. Teachers will certainly want to adapt these procedures for their class and available resources. The Learning Procedure serves as a guide and is not intended to be a script.

ones need to be built. They take up valuable land, and it seems, no one wants to live near one. This is known as the NIMBY (Not In My Back Yard) syndrome.

Activities such as recycling, reusing, reducing, and composting reduce the amount of trash and garbage that must be landfilled or incinerated. While these activities will never eliminate the need for landfills, aggressively reducing the amount of garbage flowing into landfills will extend the life of existing landfills and reduce the frequency of building new landfills.

Learning Procedure

1. Review the material on garbage in the Background portion of this lesson with the students. See the Resource Section for more information.
2. Invite the school custodian to talk to the class and ask about trash removing duties: How much of the day is devoted to removing trash? Where does the trash go? How often is it picked up? What is most of the trash composed of? How much do we throw out each week? What does it cost to throw it out?
3. Arrange a short interview with the school's trash hauler for the next time they are scheduled for a pick up. When the trash truck comes, have the class watch the removal process. Then ask the trash collector about the business: When do you start working in the morning and finish at night? How many truck loads of trash do you collect each day? Why is your truck designed the way it is and how does it work? How many schools, houses, businesses do you collect from? How many miles do you drive each day? Do you ever pick up recyclables separately? Why or why not? Where do you take the trash? What happens to it then?

(OPTIONS FOR STEPS 2 & 3: If scheduling a custodian or waste hauler proves to be inconvenient, you may want to interview them yourself outside of class and role-play the parts with the class.)

4. On the basis of the interviews, have the class construct a mural depicting all the stages in creation, collection and disposal of waste. Add specific facts learned in the interview and display the mural in the school to teach others. See sample of the art included to help students construct the mural.

Questions for the Class

1. Why are custodians and trash haulers important?
2. Where does the trash go?
3. What happens to it after it gets there?

Extension Activities

1. Take a trip to the local landfill.
2. Have students conduct similar surveys/interviews with the kitchen staff at school and at home.
3. Determine how much recyclable and/or organic waste the school produces each year and devise a recycling or composting program.

Just Do It

Do your part at home. Take out the trash and the garbage from all around the house and see that it gets put in the proper place for disposal. If there is a recycling program in your community, make sure your family participates. If there is not, write a letter to your mayor or county council. Tell them that protecting the earth today is important for tomorrow. Ask them to start a recycling program.

The **Just Do It** box suggests an action that students as individuals can perform at home with family or friends to make a difference.

Questions for the Class may be leading questions and appear before the Learning Procedure to generate interest or they may be summary questions at the end of an activity. While not all lessons have suggested Questions for the Class, teachers will want to develop their own questions to meet the needs of their students.

Extension Activities point to further exploration of the topic area. They may include independent student research or additional classroom projects. Note: the materials required for Extension Activities are not included in the list of materials in the Teacher's Box at the beginning of each lesson.

A PROCEDURAL NOTE FOR TEACHERS:

These activities have been designed to supplement South Carolina's environmental curricula and with the opportunities and limitations of the classroom teacher in mind.

It is your prerogative to adapt these lessons to your specific classroom situation. Although these lessons have been pilot tested, the developers realize ... and expect ... you, the teacher, may have to modify, supplement, or adjust the learning procedures, materials, work sheets, questions, vocabulary, etc., to meet the needs and learning experiences of your students.

We welcome your suggestions and comments so that all of South Carolina's students can benefit from *Action for a cleaner tomorrow*. Please keep us informed by using the Comment Form supplied with your copy of *Action for a cleaner tomorrow*.

A CAUTIONARY NOTE:

Some activities involve chemicals, glassware, flames, live specimens, etc. Please ensure that you and your students take proper precautions and follow accepted safety procedures. Be sure to read and identify safety precautions before starting an activity.



A South Carolina Environmental Curriculum Supplement

Action for a Cleaner Tomorrow Evaluation Form

Thank you for participating in the review of *Action for a Cleaner Tomorrow*, the South Carolina Solid Waste Curriculum Supplement. Please complete an evaluation form for each lesson on which you wish to comment. Please feel free to copy this form as many times as you need. Please complete this form as soon as possible after teaching the lesson in your class. This form and your copies of the lessons (only if they contain notes and suggestions) should be returned to the address on the back of this form.

Rating Scale**Format:**

- 1) Is the curriculum easy to read?
- 2) Is the curriculum easy to use?

Excellent

Poor

1	2	3	4	5
1	2	3	4	5

Evaluate the following format components:

- 3) Teacher Information Box (top left of page one of lesson)
- 4) Down to Earth (at the bottom of some pages)
- 5) Just Do It (at the end of some lessons)
- 6) Extension Activities (included with some lessons)
- 7) Questions for the Class (included with some lessons)

1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5
1	2	3	4	5

Activity effectiveness:

- 8) Overall effectiveness in accomplishing stated learning objective
- 9) Grade level/Vocabulary appropriateness
- 10) Background material

1	2	3	4	5
1	2	3	4	5
1	2	3	4	5

Your ideas for improving Background materials: _____

- 11) Learning procedure

1	2	3	4	5
---	---	---	---	---

Your ideas for improving Learning procedure: _____

Students' evaluation:

- 12) Students' interest in this activity
- 13) Students' understanding of concepts presented
- 14) Students' interest in environmental education

1	2	3	4	5
1	2	3	4	5
1	2	3	4	5

Are listed materials reasonable/easy to collect

YES ☐NO ☐

Your ideas for improving Materials: _____

Was the Preparation Time listed at the top of this lesson appropriate?

YES ☐NO ☐

Did you use the Resource Section provided with your lessons?

YES ☐NO ☐

Your ideas for improving the Resource Section: _____

Would you recommend this lesson to your colleagues?

Why or why not? _____

How did you incorporate this lesson into your classroom? (Did you coordinate this with text books or other materials; use books, films, videos, etc.? Which ones? Please be specific.) _____

Ideas for improving this lesson: _____

Are there any factors that limit your ability to use this curriculum in your classroom? _____

Please Print.

To assure you receive proper credit for your efforts, please return this form with your lessons.

Your Name: _____

Your School's Name: _____

Your Address: _____

Your Phone Number: _____

Subject Taught: _____ Grade Level: _____

Thank You!

Please complete and return this form to:
Haggard & White, Attn: Action for a Cleaner Tomorrow.
11 Whithorn Way, Blythewood, South Carolina 29016.

Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum Supplement

**I've been trained to use *Action for a cleaner tomorrow*,
but have a new address.
Please send any new lessons or updated information
to the address listed below.**

Please send this information to my ☐ Home Address ☐ School Address

My Name: _____

My Home Address: _____

My School's Name: _____

My School Address: _____

My Phone Number: _____

Subject Taught: _____ Grade Level: _____

- ☐ I want to share *Action for a cleaner tomorrow* with my colleagues.
Please contact me about scheduling a training session.

seal with tape

(please fold here)

Please place
stamp here.

S.C. DHEC
Office of Solid Waste Reduction and Recycling
2600 Bull Street
Columbia, South Carolina 29201

(please fold here)

Annual Environmental Competitions Encourage Students To Take an Active Role in Protecting the Environment

With the goal of encouraging students to preserve our environment, the South Carolina Department of Health and Environmental Control began a statewide educational component to Nonpoint Source water pollution in 1992. Funded through Section 319 of the Clean Water Act, the charge was to develop a comprehensive educational program to make South Carolinians aware of the part people play in contributing to water pollution. One of the approaches taken to raising public awareness was by developing programs and activities primarily geared toward partnerships and focusing on encouraging young people to become more environmentally conscious.

The **Champions of the Environment** program was an evolutionary process that began with the South Carolina Environmental Awareness Student Awards Competition for middle school students and expanded into a recognition program for students involved in environmental projects and activities at all grade levels. This two-part program is continuing its outreach activities throughout the state in a series of environmentally-oriented television spots geared toward erasing the environmental education deficit, particularly in the areas of Nonpoint Source water pollution. By producing and broadcasting television spots aimed at motivating South Carolinians to act in a more environmentally-conscious manner and implement best management practices, we will continue our goal of alleviating Nonpoint Source water pollution.

Creating a partnership with Union Camp, DuPont, WIS-TV and Riverbanks Zoo, corporations who shared similar perspectives in protecting South Carolina's natural heritage and instilling in students the need to make an environmental commitment, was a key to the program's success.

The goals of the partnership are (1) to support and enhance environmental problem solving; (2) to develop student interest in science and math education and careers; (3) to reinforce environmental achievement through positive public recognition; (4) to support the development of interdisciplinary skills; (5) to encourage personal responsibility for the health of the environment; and (6) to reward creativity and innovation for environmental projects with statewide recognition and scholarships.

The middle school component of the Champions program, called the South Carolina Environmental Awareness Student Awards Competitions, incorporates five categories of competition and culminates each April at Riverbanks Zoo in Columbia. These competitions areas include environmental awareness poster, essay, spokesperson, bowl, and project.

This component of the **Champions of the Environment** program recognizes outstanding environmental students with a television spot showcasing the student wearing the Champions medallion. The program is open to students in all grade levels who are actively seeking solutions to environmental problems. These students may work individually, as a team or as a classroom project.

The program works this way: (1) nomination forms are distributed to science teachers and others during September; (2) television spots begin with information regarding the nomination process; (3) nominations are received beginning in October, with a deadline for the 25th of each month for selecting the monthly **Champions of the Environment**; (4) the partnership advisory committee (representatives from Union Camp, DuPont, WIS and DHEC) meets and selects the monthly winners; (5) the winners tape the television spot at WIS and other locations in the Columbia area; (6) the spots are shown 25 times during the month; and (7) during May the monthly winners are evaluated to determine the scholarship recipients.

The television spots are broadcast by WIS-TV to the forty counties the station serves. It is estimated that each month the television spots reach 1,700,000 people.

At the end of the school year, the three most outstanding Champions (individuals or teams) will be chosen from the monthly winners and will be presented with \$1000 scholarships during an awards reception. If a winning Champion is a team, the team will share the \$1000 award.

The continuing goals of the cooperative public-private partnership are (1) to support and enhance environmental problem solving; (2) to develop student interest in science and math education and science careers; (3) to reinforce environmental achievement through positive public recognition; (4) to support the development of interdisciplinary skills; (5) to encourage personal responsibility for the health of the environment; and (6) to reward creativity and innovation for environmental projects with state recognition and scholarships.

Champions of the Environment develops student initiative and self-esteem through (1) peer recognition; (2) rewards through scholarship and personal achievement; (3) promotion and encouragement of environmental awareness, environmental leadership, and environmental conservation; (4) individual and group creativity; and (5) self-confidence and public speaking development.

The program is nationally recognized for its innovative approach to environmental education. **Champions of the Environment** program promotes hands-on learning by recognizing students working on exemplary environmental projects beyond the usual realm of the classroom.

For additional information on the program contact Phil Hayes, **Champions of the Environment** coordinator, SCDHEC, 2600 Bull Street, Columbia, SC 29201 or call (803) 734-5078.

**Champions of the Environment
Scholarship Recognition Program
(for students in grades 1 through 12)**

South Carolina Environmental Awareness Student Awards Competition (for students in grades 6 through 8)

Each year South Carolina's sixth, seventh, and eighth grade students are invited to demonstrate their environmental knowledge during the annual South Carolina Environmental Awareness Student Awards Competition in the Education Building and Amphitheatre of Riverbanks Zoological Park and Botanical Garden in Columbia. The event is usually scheduled in April around Earth Day.

If you are a sixth, seventh, or eighth grade teacher in South Carolina, we would like for you to encourage your students to participate in this environmental recognition program. We encourage you to show your concern and become active in protecting our precious natural resources.

There are several ways this can be done. The South Carolina Environmental Awareness Student Awards Competition has five divisions of competition with awards given in each area. These divisions are: (1) Environmental Awareness Poster; (2) Environmental Awareness Essay (500 words); (3) Environmental Awareness Bowl; (4) Environmental Awareness Spokesperson; and (5) Environmental Awareness Project. You may enter any or all divisions.

The essay, poster, project and spokesperson has a theme each year and should address the theme. The registration deadlines are determined in September of the year preceding the competitions and are available through the **Champions of the Environment** coordinator at DHEC.

Everyone entering the competition will be rewarded. Each participant will receive an Environmental Awareness Certificate for participating in the competition, personally commending the student for his/her efforts.

The four finalists in each division will be awarded \$100 savings bonds and the winners will receive \$300 savings bonds.

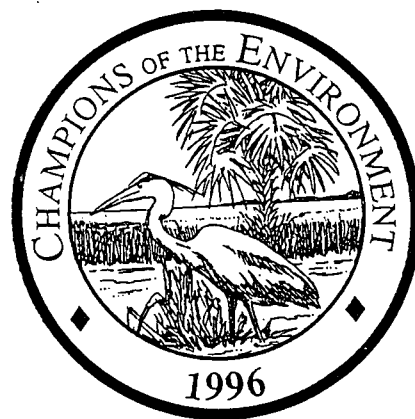
For additional information, including application forms, contact Phil Hayes, Coordinator, Champions of the Environment, SCDHEC, 2600 Bull St., Columbia, SC 29201, or call (803) 734-5078.

Essay Topic and Guidelines

(1) The essay topic is determined in September, prior to the April competition. (2) The essay length is 500 words (approximate) and should be typed (double-spaced) or neatly handwritten. If it is handwritten, it should be in ink and double-spaced on white paper, one side only. (3) Attach the entry form to your essay. Do not put your name on the essay, only on the entry form. (4) Essays become the property of DHEC and will not be returned. (5) Essays must arrive at DHEC by the announced deadline.

Poster Topic and Guidelines

(1) The topic for the poster competition is determined in



September. (2) The size of the poster is 22" x 28." A third dimension may not be used. (3) Attach the entry form to the back of the poster. Do not put your name on the front of the poster. (4) Posters may be submitted on the day of the annual competition or may be delivered to DHEC prior to the competition. (5) Posters become the property of the South Carolina Department of Health and Environmental Control and will not be returned.

Environmental Awareness Bowl Guidelines

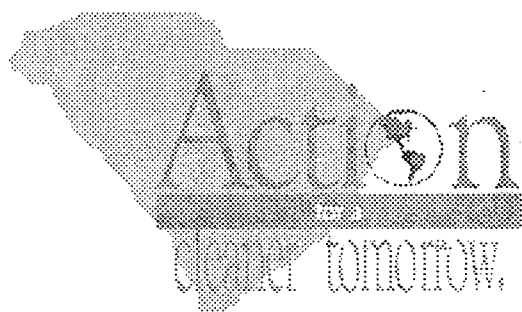
(1) Pre-registration is required for this competition and is limited. Students must be enrolled in the sixth, seventh, or eighth grade. (2) All participants qualify for the bowl by taking an environmental awareness quiz. The qualifying quiz is scheduled during the morning of the competition. Those students receiving the highest scores will become the finalists for the bowl taking place in the afternoon. (3) The competition's content areas include South Carolina's natural resources, water, soils, forestry, recycling, aquatic ecology, and current environmental issues.

Environmental Awareness Spokesperson

(1) The topic of the spokesperson category is announced in September prior to the April competition. (2) The participant will present a 45-second (time limit) commercial on the topic. The commercial must be presented live. Video commercials may not be substituted. (3) Hand-held props are permissible. (4) The competition will be judged on presentation, creativity, content, and effectiveness.

Environmental Awareness Project

The Environmental Awareness Project may be an individual, team (five maximum) or classroom project conducted during the school year to promote environmental awareness and participation. The theme for the project will be announced in September prior to the April competition. The five-page written entry (maximum typewritten) will be submitted by the announced deadline, and should include a project statement, documentation, publicity, and results. Graphs, videos, and photographs may be included as supplemental materials. During the day of the competition, the individual or team (five maximum) will present their project to a panel for final selection. There is a five minute limit on the presentation. The presentation may be followed by questions from the judging panel. The competition will be judged on the written report, presentation, creativity, and results.



A North Carolina Environmental Curriculum

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Trash Can Scan

6.1.3.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

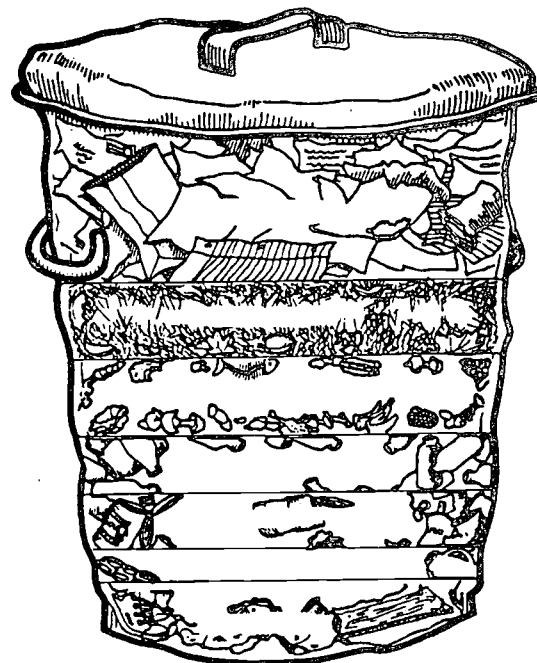
Focus: Solid waste components

Subject: Science, Math, Art

Materials: See list below

Teaching Time: One hour a day for 3 or 4 days

Vocabulary: Weight vs. volume, components, waste stream



Learning Objective

Students will:

- explore what garbage consists of and that it can vary in composition over time or by location of collection
- classify, weigh, and graph the composition of the classroom's trash
- examine the concepts of volume and weight and how different types of trash affect the quantity of solid waste produced.

Background

The **waste stream** is comprised of many different kinds of objects. Composition of trash by **volume** and **weight** can be very different. In South Carolina, the solid waste stream, measured by weight, is made up of:

- 37.6% paper
- 15.9% yard waste
- 6.6% glass
- 6.7% food
- 9.3% plastic
- 8.3% metals
- 15.6% other (includes miscellaneous wastes that cannot be categorized elsewhere such as clothing or wood).

Materials

Updated chart from the South Carolina Solid Waste Management Plan (included with this lesson), three days worth of classroom trash, gloves, scale capable of weighing in ounces or grams, old newspaper, construction paper, and/or graph paper.

Learning Procedure

1. **Ask:** What kinds of things do you throw away? What are these things made of? What materials do you think makes up most garbage?
2. Distribute the South Carolina Solid Waste Management Plan handout. Discuss the different categories of trash (*paper, plastic, metal, etc.*), and list examples of items in each category. Divide the students into seven teams, each representing one of the seven categories of trash. Have each team create trash category posters or collages using these lists



Germany, Japan, Sweden, Canada and Norway have introduced their own environmental seals. These seals indicate products that meet government standards for not harming the environment.

6-8

PAGE

1

and drawings or pictures from magazines and newspapers. Encourage students to make their posters 3-dimensional by using the actual items.

3. Collect all trash discarded by the class for several days. For sanitary reasons, exclude food but retain wrappers. Lay old newspaper on the floor, dump the trash on it, and let the students sort the trash according to category, i.e., paper, plastic, metal. For items that can fit into more than one category, have them decide which one is predominant. If many items are equally mixed, you might want to create a mixed materials, or "Other" category. Working in groups, have the students weigh each category of trash and record their results on the board.

4. Have the students create a bar graph bulletin board display that compares the various **components** of the classroom waste stream. Each material can be represented by a different colored construction paper bar or to make the board 3-dimensional, use crushed pieces of the actual material. For example, crush aluminum cans and stack them up to represent the quantity of aluminum in the classroom waste stream. Determine the scale to be used (e.g., two vertical inches equals one ounce, etc.).

5. Repeat this activity for three separate trials, each time separating and weighing the trash, recording the data, and constructing a bar chart. Students may also calculate the three-trial average. Have the class graph the results.

6. Compare your classroom results to the figures on the handout. What are the differences and similarities? Did the time of week when the trash was collected affect the results? Why? Would the time of year or season affect the results?

7. Ask the students if all the items they throw away are the same size and weight. Have them name some examples that are small, large (bulky), light, heavy, etc. Ask the students to predict which materials make up the greatest portion of waste by volume, by weight, and by number of items.

A. Using the trash collected in the classroom for a week or a sample trash can of items prepared in advance, have the students separate it into the different categories of materials — glass, plastic, paper, metal, etc.

B. Ask the students which category do they think is the heaviest? Which takes up the most room? Which contains the greatest number of pieces? Have the students write down their answers in order of heaviest to lightest, bulkiest to most compact, and most to least numerous.

C. Weigh each category of items. For the paper category, material could be divided into newspaper, cardboard, writing paper, and other. Then place the objects in a clear container and determine their volume by measuring how much space they occupy (width, depth, and height). Count the number of items. Make a chart on the board showing the weight, volume, and number of pieces of each category. Make a bulletin board display using different colored blocks to represent each part of the waste stream. Make one trash can showing the trash content by weight, another showing trash content by volume, and a third showing trash content by number of items. For each category of waste, cut out a band of paper representing its percentage of the total, so that when stacked one above the other, the three trash cans are full. What are the implications of these differences in terms of waste disposal?

D. Discuss how weight and volume of trash are both important in its disposal. (*Bulky items may not weigh much, but may take up more space in the landfill or trash compactor. See the Landfill Volumes chart included with this lesson.*) How might the volume change if glass, cans, or boxes are crushed? Does the weight change if the volume changes?

Extension Activities

1. Have the different groups survey trash cans from other areas of the school (other classrooms, the library, the gym) or home, and compare the results with those obtained in your classroom. Does the

composition of the waste stream vary at each location? If so, why? Discuss differences and similarities of the trash from different locations. Predict the results of this type of trash analysis using the garbage from department stores, supermarkets, factories, and other institutions. What would be some of the differences and similarities in the composition and amount of waste? Why?

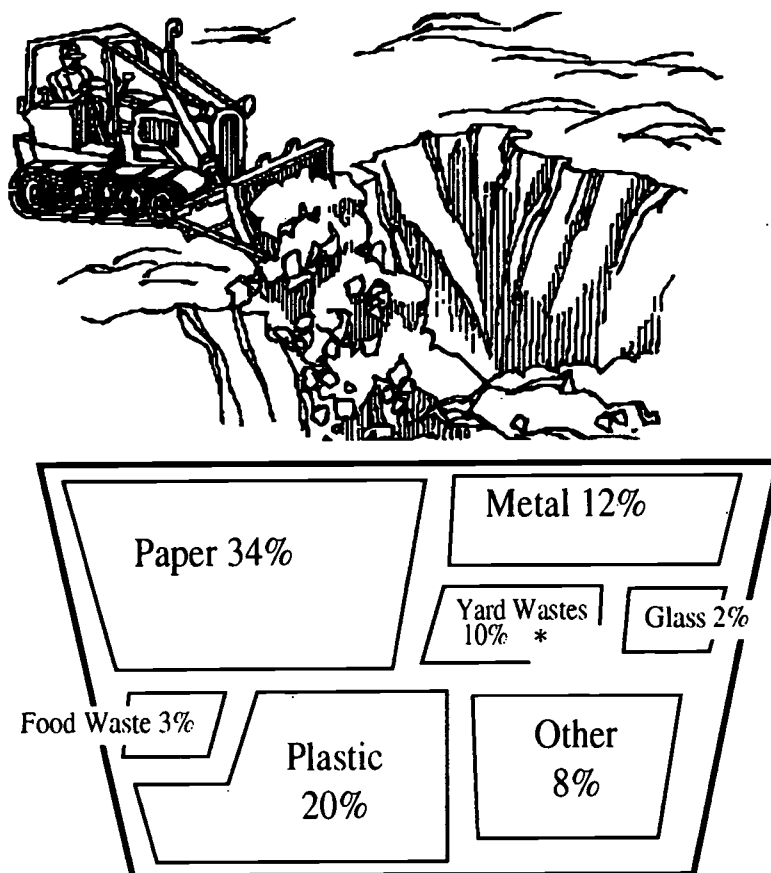
2. Extend the exercise by asking what other sorts of items are thrown away that were not represented in the trash can: yard wastes, white goods (refrigerators, washing machines), tires, etc. Where do they fit into the spectrum? Tell the students that these are called "special Wastes" and are banned

from South Carolina's landfills. In fact, there is a \$2 per item tax on white goods, tires, and lead-acid batteries paid at the time of purchase to help defray the cost of disposing of these special wastes.

Just Do It

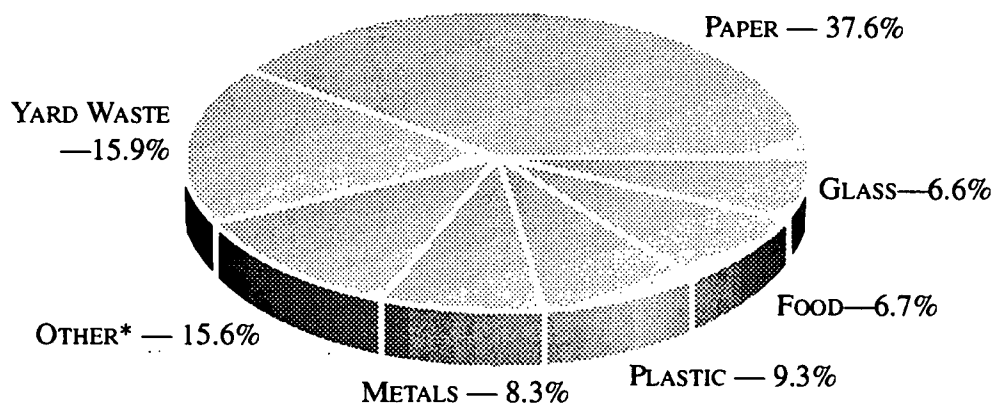
Visit or write the local landfill to discover how South Carolina's garbage is measured.

Landfill Volumes



* Note: Yard wastes are now banned from South Carolina landfills.

SOUTH CAROLINA SOLID WASTE STREAM CHARACTERIZATION † **PERCENTAGE BY WEIGHT**



* Other includes miscellaneous wastes that cannot be categorized elsewhere.

† This solid waste stream characterization includes residential, commercial, industrial, agricultural, governmental, and all other solid wastes that are disposed in municipal solid waste landfills.

Population & Garbage

6.1.4.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Affects of population growth on garbage

Subject: Math, Science

Materials: Student worksheet, graph paper, colored pencils or pens

Teaching Time: Two class periods

Vocabulary: Per capita, growth rate

Learning Objective

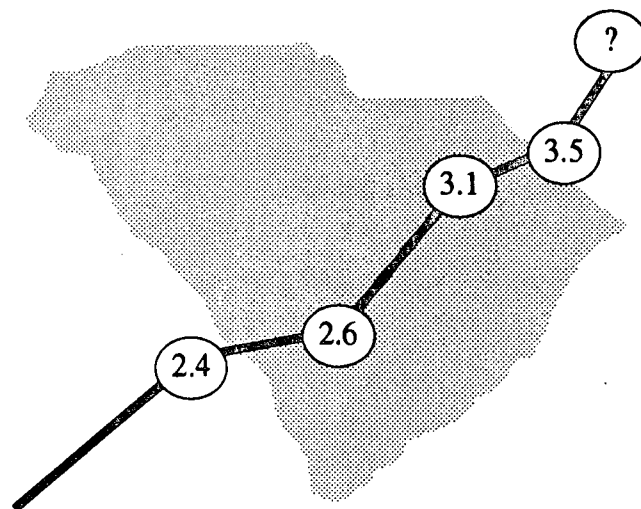
Students will:

- describe population growth
- describe growth in the amount of solid waste per person as factors that influence the amount of solid waste generated in South Carolina.

Background

South Carolina's population is 3.6 million and it is expected to reach 4.5 million by the year 2010. (To illustrate 3.6 million people, note that the football stadium at the University of South Carolina holds 70,000 people. You would need more than 51 of these stadiums to hold the entire population of South Carolina.)

This population **growth rate** means more jobs and a growing economy. It also means more water pollution from sewage and industries, more air pollution from cars and more solid waste. More and more people find South Carolina an attractive place to live, but each South Carolinian is producing more household waste and requiring more consumer goods which results in increasing industrial wastes from manufacturing. In addition, South Carolina's mountains and beaches are popular tourist



attractions bringing millions of people (and their garbage) into the state each year. This increase in waste production **per capita** (or per person) is increasing faster than the population. It is the combination of more people and more waste that is causing the garbage glut in South Carolina.

Learning Procedure

1. Copy the chart *Population & Garbage: South Carolina's Trend* onto the board or make a transparency of the chart included with the lesson. Use either standard or metric measurements.
2. Ask students to describe the numbers in the table. What do they show?
3. Tell students that, using the information from this chart, they are going to graph and predict waste trends of the future. Have students set up their graphs with year on the x-axis (horizontal) and the population in millions on the y-axis (vertical). The graph should begin in 1960 and end in 2020. Ask



The average resident of India has less than one-tenth the water for drinking, cooking, washing, and bathing than the average Canadian.

students to prepare a line graph based on the population data from the *Populations & Garbage: South Carolina's Trend* chart that you have written on the board. Then, ask students to project the population data to 2020.

4. Use the data on solid waste production per capita from the *Populations & Garbage: South Carolina's Trend* chart that you have written on the board to make a second graph on the same sheet of graph paper. (Use a different color marker to make it easy to read.) Help students modify the y-axis so it records solid waste data in pounds per person per day. Ask students to extend the data to 2020.

5. Based on the data in the graphs, have students answer the following questions (see attached worksheet):

- According to your graph, which is growing faster, South Carolina's population or the amount of waste that is produced per person?

- Calculate the average growth rate for South Carolina's population per year between 1980 and 1990. Calculate the growth rate for waste production per person per year for the same decade.

- If each South Carolinian produces 5.6 pounds (2.52 kg) of solid waste per day, how much will be produced by 3.5 million people in a day? In a year? (NOTE: the 5.6 pounds [2.52 kg] of solid waste generated by each South Carolinian is household waste only. Including industrial waste raises the figure to ten pounds of waste per person per day.)

- Assume one week's worth of trash (7 days x 5.6 pounds [2.52 kg]) of solid waste takes up 1 cubic foot (0.028 cubic meters) of landfill space after it is crushed. Solid waste is normally compacted to 750 - 1,000 pounds per cubic yard. (339.75 kg - 453 kg per 0.765 cubic meter) How many cubic feet (meters) of landfill space are required per person per year?

- Assuming a population of 3.6 million people and 39.2 pounds (17.64 kg) of solid waste per person per week (1 cubic foot or 0.028 cubic

meters), how many football playing fields would be required to hold all the waste that is produced in one year? Assume the field is filled to a height of 10 feet (3 meters). (Note: Ask your PE teacher to mark off a regulation football field so students can visualize the volume of waste.)

Questions for the Class

1. Write a paragraph that describes the relationship between population growth and the growth of solid waste per person. Evaluate how growth effects landfills and how landfills effect the population.

2. Write a paragraph with your ideas about how South Carolina can balance growth and solid waste.

Extension Activities

1. Compare South Carolina's population growth with growth figures for the United States (or a single state of the students' choosing). What similarities and differences exist?

2. Is South Carolina's population concentrated in just a few areas? Use recent South Carolina population figures and an outline map of the state to identify the largest concentrations of people. Where would you expect to find the most garbage? (See the South Carolina Solid Waste Management Plan's chapter on the Future of Solid Waste in South Carolina. Check your local library or contact DHEC at 1-800-76 USE-IT.)

3. Find out how the population in your town and county is projected to change over the next five years, 10 years, and 20 years. Who makes these projections and how do they make them? (*Contact your town and/or county planning commission, the South Carolina Department of Commerce, or refer to the South Carolina Solid Waste Management Plan, 1991.*)

Just Do It

We can control how much waste we produce. Develop a plan to reduce the amount of waste your family produces and then put that plan to work.

Population & Garbage: South Carolina's Trend

YEAR	POPULATION (in millions)	WASTE (in lbs./person/day*)
1960	2.4	2.66 (1.18 kg)
1970	2.6	3.27 (1.48 kg)
1980	3.1	3.61 (1.64 kg)
1990	3.6	5.6 (2.52 kg)
1995		
2000		
2010	4.5	
2020		

(* Includes each person's portion of all
household waste generated in the state.
Does not include industrial waste.)

Name: _____

South Carolina Population & Garbage

After you have completed your graph, answer the following questions (show your work):

1. According to your graph, which is growing faster, South Carolina's population or the amount of waste that is produced per person?

2. a) Calculate the average growth rate for South Carolina's population per year between 1980 and 1990.
b) Calculate the growth rate for waste production per person per year for the same decade.

3. If each South Carolinian produces 5.6 pounds (2.52 kg) of solid waste per day, how much will be produced by 3.6 million people in a day? In a year?

4. Assume 5.6 pounds (2.52 kg) of solid waste takes up 0.5 cubic feet (0.014 cubic meters) of landfill space after it is crushed. How many cubic feet (meters) of landfill space are required per person per year?

5. Assuming a population of 3.6 million people and 5.6 pounds (2.52 kg) of solid waste per person per day (0.5 cubic feet or 0.014 cubic meters), how many football playing fields would be required to hold all the waste that is produced in one year? Assume the field is filled to a height of 10 feet (3 meters).

Death of a Lake

6.1.5.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 - 8

Focus: Waste and water

Subject: Science

Materials: Water test kit (available at aquarium supply stores or biological supply catalogs, can also use pHdriion paper or pH meter to measure pH), a box for each student or group of students, handout sheets included in this lesson

Teaching Time: 3 class periods plus homework assignments

Vocabulary: Acidity, alkalinity, acid rain, fossil fuels, organic, pH



Learning Objective

Students will:

- identify the pH level at which various members of an aquatic system are affected and eventually die
- describe the changes caused by increasing acidity in the ecosystem of a lake.

Background

While there are many factors that contribute to the health of a body of water such as temperature and oxygen levels, this lesson will concentrate on the effects of changes in the **pH** of water. The pH level is a common measure of **acidity**. The pH scale ranges from 0 to 14. A value of 7 represents a solution that is neutral. Values greater than 7 indicate **alkalinity**; values less than 7 indicate **acidity**. In South Carolina, the Department of Health and Environmental Control has established

a standard healthy pH range between 6 and 9 for surface water.

Even after several years of heavy rains, a lake's natural buffers keep it somewhat alkaline. However, the sudden flush of acid runoff from melting snow and ice, or repeated doses of **acid rain**, can markedly lower a lake's pH level.

Changes in pH may change the populations and/or distributions of the water's inhabitants, putting stress on competing organisms. As the pH level of a lake goes down, the diversity of aquatic life is reduced. (Note: Many South Carolina waters, such as blackwater rivers like the Edisto and Ashepoo, have naturally occurring low pH due to high levels of tannic acids from trees and plants. These waters sustain plant and fish life that have adapted to low pH environments.)

DOWN TO EARTH



While the United States has changed its practices in building dams that pose environmental dangers, little has changed in many other countries. Some of the largest potentially environmentally damaging water projects are now planned in Canada, Mexico, China, Chile, and Vietnam. Each of these projects is driven by one imperative: to produce more electric power to raise the national standard of living to a level comparable to that of nations like the United States that already have their dams in place.

Source: 1993 Environmental Almanac

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Major sources of acid precipitation are sulfur oxides and nitrogen oxides. Sulfur oxides are produced by the burning of **fossil fuels**, mostly coal. Nitrogen oxides are from automobile emissions. Although air pollutants seem to be a different issue, air emissions are a contributor to water pollution.

According to the U.S. EPA's *National Water Quality Inventory: 1990 Report to Congress*, South Carolina has 3,594 river miles (5,784 km) that have been evaluated to determine if they meet the criteria for safe fishing. Of these, 3,230 miles (5,198 km) were found "fishable." The state has also evaluated 3,438 miles (5,533 km) to determine if they meet the criteria for safe swimming; and of those 2,010 miles (3,235 km) were deemed safe for swimming.

Learning Procedure

1. Have the students bring water samples from local ponds or lakes to class. Remind them to include the following information with their specimens: location where the sample was taken, human activity on or in the water, human activity near the water (homes, farms, industry, business). Make sure the containers for collecting the water are clean, have no detergent residues and it might be safer if they only use plastic containers.

- Use a water test kit (or other method) to find the pH level of the samples. Based on the water test results, have the students describe the health of the water in terms of its pH level. What life might they expect the water to support, and what would they not expect it to support?

- If any of the examples have a pH level below 7.0, examine the information about the location of the sample sources and the human activity on, in, and near the water. Can the students think of possible explanations for the results of the pH tests? What are the implications for their community? What could be done about acid pollution in our lakes and streams.

2. Give each student or have students bring to class a box decorated to look like a lake. Have them name their lake. (Option: use a single piece of blue construction paper.) Tell them this represents a healthy lake with a pH level of 8 ... slightly alkaline.

- Make copies of the teacher sheet *Flora and Fauna*, included. Cut them into cards. In each "lake" (box/construction paper), place the cards representing various inhabitants of the lake. Each lake could have a set of cards slightly different from the other lakes.

- Give each student a copy of the student sheet *Lakes*, included. Direct the student to change their lakes as the pH drops. Read aloud each pH level, the flora and fauna affected, and the lake conditions. With each item you read aloud, have the students remove the appropriate cards from their lakes. With each drop in pH level, discuss the damages done to the lake. Compare the results to the healthy lake.

Questions for the Class

1. What is the pH level of a healthy pond or lake? Compare and contrast the flora and fauna of a healthy lake with those of a lake that has a pH level of 4.5 or lower.

2. Why should we be concerned about the pH levels of ponds and lakes?

Extension Activities

1. Have students illustrate the various stages of the Death of a Lake. Have them research the lake's inhabitants and prepare short descriptions to go with the illustrations.

2. Pick a local lake or river and research the flora and fauna found there.

3. Research other sources of water pollution such as industrial sources and municipal sewerage.

Investigate the role of municipal waste water treatment plants in cleaning sewerage before it is discharged into rivers.

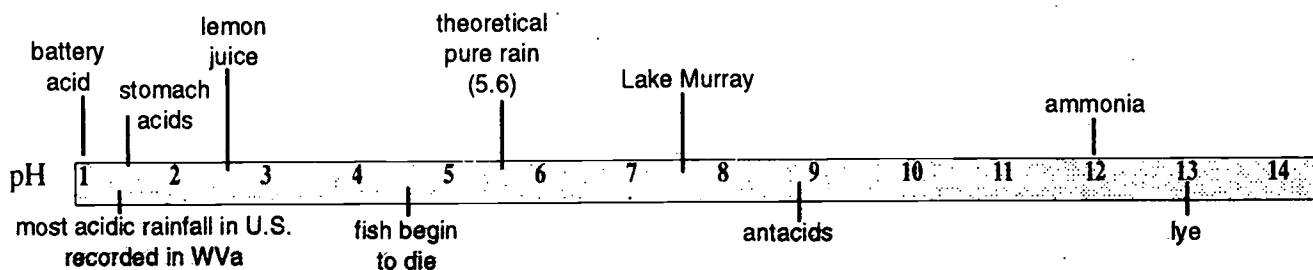
4. Can a lake or river ever become too alkaline? How does this happen and what will it do to the flora and fauna?

5. Do you think a lake with a low pH level can be restored to a healthy state? How do you think this could happen? (*Yes it can. Have students research the health of the Great Lakes over the past three decades.*)

Just Do It

Research and report on the level of acidity of local lakes, streams, and ponds over six months.

Typical pH Levels



FLORA & FAUNA

salamander eggs Species A	salamander eggs Species B	snails	tadpole shrimp	plankton
bacterial decomposers	trout	small-mouth bass	catfish	fauna
aquatic life	bream	suckers	bream	(fish)
frogs	many insects	back swimmers	water boatmen	water striders
sphagnum	algae-fungal growths	(fish)	(fish)	(fish)

LAKES

<u>pH Levels</u>	<u>Inhabitants</u>	<u>Conditions</u>
8.0	All inhabitants	Healthy
7.0		Calcium begins to decline.
	Salamander eggs <i>Species A</i>	Fail to hatch in small breeding ponds adjacent to lake, possibly because of the disruption of the delicate nutrient exchange process within the eggs.
6.6	Snails	Begin to die.
6.0	Tadpole shrimp	Cannot be found.
	Salamander eggs <i>Species B</i>	Fail to hatch.
6.0 – 5.5	Bacterial decomposers	Begin to die; leaves and other organic debris collect on the lake bottom.
	Plankton	Start to drop out, depleting the base of the food chain.
	Trout & small-mouth bass	The disrupted calcium balance begins to upset the exchange of ions across the gill membranes.
	Catfish	Production of eggs prevented.
5.9	Many fish	Toxic metals (aluminum, mercury, lead, cadmium, beryllium, nickel) are released from lake-bottom sediments or leached from surrounding soils. Aluminum toxicity damages the gills, which produces a protective mucus. Without this protective mucus, gills physically erode, suffocating the fish.
5.5	Aquatic plants	Acidophilic mosses, fungi, and filamentous algae have nearly choked them out.
	Bream, suckers	Mature fish die from lack of food, gill damage, or toxicity; eggs produced cannot survive.

LAKES
(continued)

<u>pH Levels</u>	<u>Inhabitants</u>	<u>Conditions</u>
5.0	Fauna	Starve because calcium is being used by sphagnum moss, which is usually a land plant but thrives in acidic water.
4.5	All fish, frogs, many insects	Die.
	Backswimmers, water boatmen, water striders	Tolerate acidity; thrive without predators.
	Sphagnum, algae, fungal growths	Form tight mat on the lake bottom and may change the release of some nutrients from the sediments.

The lake is deceptively clear and blue because all microorganisms have been wiped out. Blown-in organic debris (i.e., leaves) falls unscathed to the lake's bottom. Very low rates of bacteria eventually consume all the oxygen under the dense mat of mosses, algae, and fungi. Anaerobic bacteria take over, producing carbon dioxide, methane, and hydrogen sulfide. The entire ecosystem on the lake has been changed.

Bikes & By-products

6.1.7.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Hazardous waste, natural resources, manufacturing by-products

Subject: Social Studies, Science

Materials: Diagram *Bicycle materials, wastes & by-products*, a bicycle

Teaching Time: One class period

Vocabulary: Hazardous waste, by-products, toxic, flammable, combustible, reactive, corrosive



Learning Objective

Students will:

- learn what the term hazardous waste means
- learn some of the hazardous wastes created by the manufacturing of a bicycle
- understand how making many of the things that we *do want* creates things that we *don't want*.

Background

Hazardous waste disposal makes the headlines often in South Carolina because the state has one of the only two hazardous waste landfills in the Southeast, one of just 32 in the nation. This hazardous waste landfill in Sumter County receives about 135,000 tons of toxic waste each year. For more information about hazardous waste, see the Resource Section.

Hazardous wastes are used as fuel for cement kilns in Orangeburg and Dorchester counties. In 1991, 133,000 tons of toxic waste fueled these kilns.

Hazardous waste incinerators in Spartanburg County and York County burn about 43,316 tons of

toxic waste. Medical wastes are incinerated also in the state at a facility in Hampton County that burns more than 16,000 tons of waste annually.

The U.S. EPA is responsible for monitoring the handling and disposal of hazardous wastes and regulates and enforces the laws that determine how wastes must be handled. These laws require waste management companies to use the Best Demonstrated Available Technology. Some wastes must be processed and recycled, some must be completely destroyed, and others must be detoxified and disposed. As technology advances the methods of handling and disposing of wastes, so do the EPA regulations.

Learning Procedure

1. **Ask:** How many of you have bicycles? What materials are used to make them? What are the frames made of? How about the tires? Where are the metal and rubber and plastic that go into bicycles made? (*In mills and factories that*



One hundred separate hazardous materials are used to make one bicycle.

Source: Science Applications International Corporation

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transform raw materials such as petroleum, bauxite, and iron ore into bicycle components.)

Ask: What makes your bike special ... different from others? How many different colors of bikes do we have? Whose bike is shiny? What is the shiny metal on the bike called? Which natural resources are used in making bikes? (*Iron and petroleum for plastics, synthetic fibers, and synthetic rubber; petroleum distillates for paint and paint solvents; bauxite for aluminum; chrome; coal for coke to smelt the iron ore into steel; and others.*)

Ask: What had to happen to the natural resources before they could be used to build your bike? (*They had to be processed in factories.*) Direct the discussion to the fact that when materials are processed, by-products and waste are also produced. Some of this waste is harmful if not properly managed.

Ask: What are **by-products**? For example, what by-products are produced when you burn wood and paper in your fireplace at home? Are some of these by-products harmful? What about when you bake a cake? Are there leftover materials? What happens to them?

2. Distribute the handout, *Bicycle materials, wastes & by-products*. Using a bicycle in class, guide students in identifying the bike's component materials. (*Steel, synthetic rubber, plastic, chrome, synthetic fibers, aluminum, paint, etc.*) Referring to the diagram, point out some of the by-products and wastes resulting from the manufacturing of these components.

3. Explain that some of the by-products and wastes from making a bike are hazardous. Discuss what hazardous means. (*Hazardous means dangerous. Hazardous wastes products and materials leftover from the manufacturing process that are likely to cause harm to the environment or humans because they are either toxic, which means poisonous; combustible or flammable, which means they burn easily; reactive, which means they explode easily; or corrosive, which refers to substances that rapidly eat into and/or dissolve what they touch.*)

Ask: Does this mean that you will get sick from handling or riding your bike? Why not? What happened to the hazardous by-products and wastes

produced when your bike was made? (*Some were captured and recycled for industrial reuse. Some are captured and disposed of in hazardous waste disposal sites. Some escape into the air and water. Some are dumped or stored illegally.*)

Ask: How should hazardous wastes and by-products be managed? Why is it important to use great care in handling these wastes?

Ask: Because hazardous wastes and by-products are made when bikes are built, should we stop making bikes? What should we do that makes more sense?

What are some other things that you use and buy that might also produce hazardous waste by-products when they are made?

Questions for the Class

1. What raw material is plastic and synthetic rubber made from?
2. What happens to hazardous industrial wastes?

Extension Activities

1. Have students select a popular item they use often and track down how it is made and the by-products that result.
2. Have students visit, call or investigate a manufacturing plant in your area to ask about by-products and hazardous wastes.
3. Have students write for current hazardous waste information from the U.S. EPA.

U.S. Environmental Protection Agency
Office of Communications & Public Affairs
401 M St. SW PM211B,
Washington, DC 20460

Just Do It

Learn more about by-products by writing the manufacturing facilities in your area and asking them what happens with what's left over!

Go Ahead ... Make a Bicycle

Can you list the parts made of these materials ... can you list the by-products & waste?

Note to teachers: Don't expect students to be able to list the by-products & waste.

Chromed and Plated Metal Parts

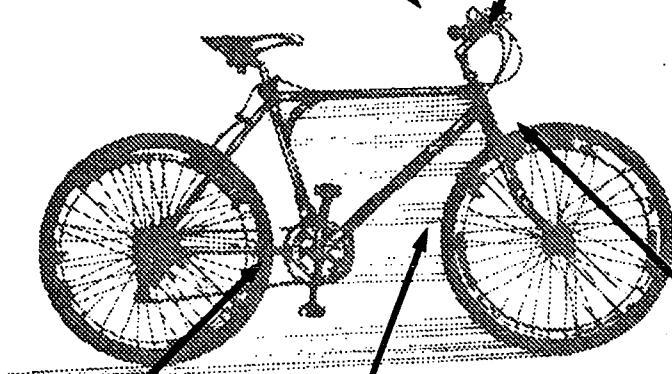
Materials: Chrome, nickel,
copper, zinc

By-products and Waste:
(Highly toxic liquid wastes)
Acids, chromium, zinc, copper
nickel, tin, cyanides

Handle Bar Grips, Plastic Seat Cover, Synthetic Fibers, Synthetic Rubber Tires

Materials: Petroleum and
petroleum distillates

By-products and Waste:
Waste oil from leaks,
caustic and acid sludge,
alkaline and acid waters,
acid gases and filtering
clays



Frame and Other Metal Parts

Materials: Iron ore and
coal to make steel

By-products and Waste:
Ammonia, tar, acids,
(pickling liquor), blast
furnace flue dust

Fenders and Other Metal Parts

Materials: Aluminum
(from bauxite)

By-products and Waste:
Large volumes of "Red
Mud," consisting of iron,
titanium and silica

Paints and Coatings

Materials: Pigment,
solvents, resins, cleaner

By-products and Waste:
Paints, solvents, cleaners

Go Ahead ... Make a Bicycle

Can you list the parts made of these materials ... can you list the by-products & waste?

Chromed and Plated Metal Parts

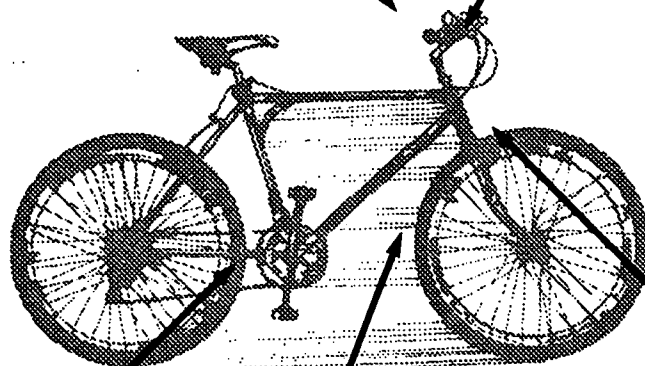
Materials:

By-products and Waste:

Handle Bar Grips,
Plastic Seat Cover,
Synthetic Fibers,
Synthetic Rubber Tires

Materials:

By-products and Waste:



Frame and Other Metal Parts

Materials:

By-products and Waste:

Fenders and Other Metal Parts

Materials:

By-products and Waste:

Paints and Coatings

Materials:

By-products and Waste:

Hazardous Waste In My Home Town?

6.1.8.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 – 8

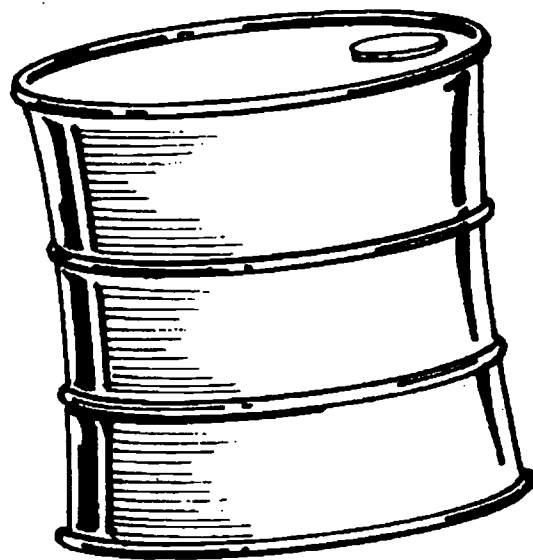
Focus: Hazardous waste generation, hazardous substances, community right to know

Subject: Social Studies, Geography, Economics

Materials: See list below

Teaching Time: One to four class periods

Vocabulary: Toxic and hazardous waste, by-products, bioaccumulation, acute and non-acute hazardous waste, small quantity generator



Learning Objective

Students will:

- identify local commercial and industrial waste generators
- identify ways we benefit from products or services that produce hazardous waste during the manufacturing process
- learn where to get information about hazardous waste.

Background

All businesses, large and small, generate waste, from simple office paper to tons of industrial wastes. Some of this waste is **hazardous**. The **toxic wastes** produced by large firms in the chemical, pulp and paper, and steel and aluminum industries are obvious, but many small businesses that are found in every community also generate hazardous wastes. These hazardous waste producers include such operations as auto body repair shops, photo processing shops and dry cleaners. "High-tech" companies that manufacture computer chips and electronic circuits are often thought of as "clean" industries. However, they too produce sometimes large quantities of hazardous **by-products**.

Because many areas of South Carolina are primarily agricultural, wastes from farms are a concern. Nationally, the use of farm chemicals has increased dramatically. Farmers pour 20 million tons of fertilizer on their land every year, almost triple the 1960 rate. Herbicide and pesticide use has increased nearly 64 percent since 1964.

According to state and federal regulations, a business that generates less than 220.26 pounds (100 kilograms) of non-acute hazardous waste per month or less than 2.2 pounds (1 kilogram) of acute hazardous waste per month is classified as a **small-quantity generator** of hazardous waste. An **acute hazardous waste** is waste that poses a more serious threat to human health and the environment. Examples of an acute hazardous material would be fluorine and sodium cyanide. Any other type of hazardous waste, such as substances with less than five parts per million of lead or any amount of TCE (tetrachloroethylene), is classified as **non-acute**.



Industry produces nearly twice as much hazardous waste and 42 times as much solid waste as households in the United States.

Source: 1993 Environmental Almanac

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Small-quantity generators may send their waste either to a specially designed hazardous waste landfill or to the local sanitary landfill without having it specially treated. They also do not have to submit quarterly reports or obtain a U.S. EPA identification number.

Companies that generate between 220.26 pounds (100 kilograms) and 2,202.64 pounds (1,000 kilograms) of non-acute hazardous waste each month or between 2.2 pounds (1 kilogram) and 220.26 pounds (100 kilograms) of acute hazardous waste each month are considered regular small-quantity generators. While these companies are not subject to quarterly reporting requirements, their waste must be treated prior to disposal in specially designed hazardous waste landfills. Companies who create more than these monthly quantities of hazardous waste, acute or non-acute, are no longer considered small-quantity generators. South Carolina has approximately 900 small-quantity generators. (For more information on hazardous waste, see the Resource section. You can also contact DHEC at 1-800-76-USE-IT for its annual report entitled *Hazardous Waste Activities Reported in South Carolina*.)

Materials

Teacher/Classroom materials

- Local telephone yellow pages
- South Carolina Industrial Directory

(Available in most public libraries. Call the South Carolina Department of Commerce in Columbia at (803) 737-0400. If you can't locate a copy, the Department of Commerce can send you information about your county.)

- Transparency or handout: *Some Industrial and Commercial Hazardous Waste Categories* (Answer key)

- EPA brochure *Protecting Our Ground Water*, Environmental Protection Agency, Office of Public Affairs, Washington, D.C. (optional)

Student materials

- Map of your community or county, contact the city or county planning office (optional)

- Handout: *Businesses Generating Hazardous Materials*

- Handout: *Some Industrial and Commercial Hazardous Waste Categories* (blank worksheet)

Questions for the Class

1. What characteristics make waste hazardous?
2. What are three types of small businesses that generate hazardous waste?
3. What are heavy metals and why are they hazardous?

Learning Procedure

1. Ask students to think of as many different kinds of businesses and industries in their area as possible. Use the Yellow Pages, the South Carolina Industrial Directory, or ask your Chamber of Commerce for information. Make sure that both large and small businesses are included.

As local businesses and industries are identified, have students describe what products or services these enterprises provide. Tabulate the number and kind of industries on the board.

Discuss how these products or services benefit us. (For example: *dry cleaners clean our sweaters and suits; automotive body shops repair or customize our cars; printing shops prepare brochures, flyers, newspapers, etc., that keep us informed.*)

2. Ask: What wastes might be produced by these local businesses and industries? How are these wastes managed? (They're either recycled, go to a landfill, or are released into the sewage system for treatment. If they are hazardous, they may be reused, recycled, stored, treated, disposed of by way of a hazardous waste landfill or incinerator, and some are disposed of illegally.)

3. Ask: What qualities might be characteristic of a hazardous waste? Under what conditions can a hazardous waste pose a threat to human or animal life? (For example: *persistent substances lasting a long time in the environment before being broken down into something less hazardous; long-term*

exposure to certain substances at low levels; bioaccumulation of substances; reactive effects; heightened sensitivity of certain groups of people to specific substances, such as young children to lead, a heavy metal.)

4. Distribute copies of the handout *Businesses Generating Hazardous Materials*. **Ask:** Did we find any of these kinds of businesses in our community?

5. Pass out copies of the blank *Some Industrial and Commercial Hazardous Waste Categories* sheet. Ask students to match the categories with the hazard characteristics discussed by filling in the "blank" column. Explain that any category may have more than one characteristic, or may have long-lasting dangers or affect certain groups of people. Ask students to think of ways wastes might cause harm. This can be done individually or in groups using brainstorming techniques. Give students ten minutes or so to work on their answers. Using the *Some Industrial and Commercial Hazardous Waste Categories* answer key, go over students' answers. **Ask:** How can we find out more about the hazardous wastes generated in our community?

6. Identify the S.C. Department of Health and Environmental Control as a good source of information about hazardous substances and hazardous waste. Tell students that a hazardous *product* becomes a hazardous waste when it is no longer wanted or useful and is destined for disposal. While the product is still considered useful, it is termed a hazardous *substance*. Discuss the principle that all citizens have a right to know about hazardous substances in their community.

7. Distribute the U.S. EPA brochure *Protecting Our Ground Water*. **Ask:** What are some of the ways wastes can enter the environment? Distribute maps of your town or county, or have students draw maps. Have students locate and mark the local landfill, and sewage treatment plants. Have them highlight streams, lakes, and salt water. Discuss the significance of these locations. **Ask:** Is hazardous waste generated near any of these sensitive areas?

8. Using the list of businesses, have students mark the locations where hazardous wastes might be produced on their maps. When maps are complete, **Ask:** Which areas in our town or county are most vulnerable or sensitive to pollution? (*Aquifers and wetlands, for example.*)

9. **Ask:** What can we do to prevent pollution? How can we ensure that our environment and human or animal health are not endangered due to hazardous wastes in our communities? Explain to students that, to protect public health and the environment, hazardous waste is managed by a system much stricter than for non-hazardous waste.

Explain that the S.C. Department of Health and Environmental Control is responsible for regulating hazardous waste and that one part of this responsibility is the monitoring of businesses that produce hazardous waste.

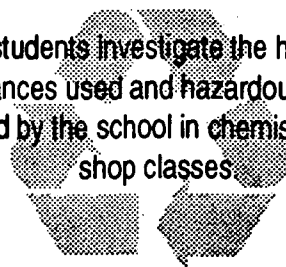
Extension Activities

1. Have students call or write the S.C. Department of Health and Environmental Control with questions about the wastes that may be generated or the hazardous substances stored in their community. Or contact the U.S. EPA at 1-800-535-0202.

2. Assign a particular waste or waste-generating business to a group of students to research. For example, a group (or individual) might try to find out what are the specific hazards associated with the wastes generated by auto detailing shops, print shops, or dry cleaners.

Just Do It

Have students investigate the hazardous substances used and hazardous wastes generated by the school in chemistry labs and shop classes.



Businesses Generating Hazardous Materials

<u>Type of Business</u>	<u>Hazardous Wastes Generated</u>
Auto Repair and Maintenance	Acids/Bases Heavy Metals Solvents
Building Cleaning and Maintenance	Acids/Bases Solvents
Cleaning Agents and Cosmetics	Acid/Bases Heavy Metal/Inorganics Solvents
Construction	Acids/Bases Solvents Preserving Agents
Electric and Computer Chip Manufacturers	Acids/Bases Spent Plating Wastes
Farmers and Agricultural Service Shops	Pesticides Solvents
Furniture/Wood Manufacturing/ Refinishing	Solvents
Laundries and Dry Cleaners	Dry Cleaning Filtration Residues Solvents
Motor Freight Terminals and Rail Transport	Acids/Bases Lead-Acid Batteries Heavy Metals/Inorganics Solvents
Printing Industries	Acids/Bases Heavy Metals/Inorganics Ink Sludges Spent Plating Wastes
Schools, Labs, and Vocational Shops	Acids/Bases Solvents Heavy Metals/Inorganics
Wood Working (Lumber mills, etc.)	Preserving Agents

Some Industrial and Commercial Hazardous Waste

Categories - Answer Key

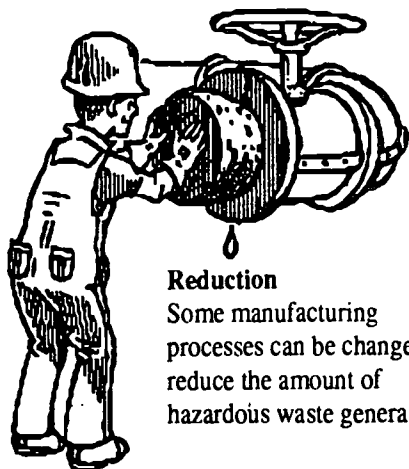
<u>Waste Category</u>	<u>Hazard Characteristic(s)</u>	<u>Other Considerations</u>
Acids/Bases	Corrosive, Reactive	Can sometimes react violently with water
Cyanide Wastes	Toxic	
Filtration Residues	Corrosive, Reactive, Toxic	
Formaldehyde	Toxic	Sensitive populations - (1)
Heavy Metals and Inorganics	Toxic	Persistent; sensitive populations - (2)
Ink Sludges	Toxic	Persistent; sensitive populations - (2)
Oils (used)	Toxic	Persistent; sensitive populations
Pesticides	Toxic	Persistent- (3)
Preserving Agents	Toxic, Corrosive	
Solvents/ Degreasers	Corrosive, Reactive, Ignitable, Toxic	Sensitive populations - (1)
Spent Plating Wastes	Corrosive, Toxic	

1. Some individuals are especially sensitive.
2. Children are especially at risk to lead exposure.
3. Chlorinated pesticides can bioaccumulate.

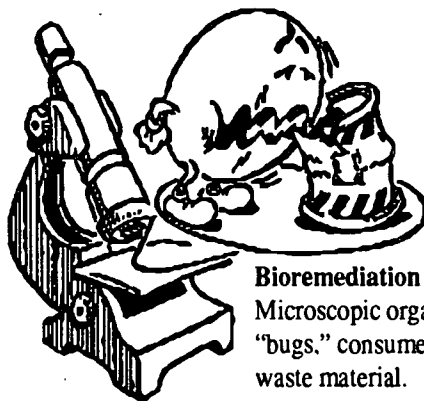
Some Industrial & Commercial Hazardous Waste Categories
Worksheet

<u>Waste Category</u>	<u>Hazard Characteristic(s)</u>	<u>Other Considerations</u>
Acids/Bases		
Cyanide Wastes		
Filtration Residues		
Formaldehyde		
Heavy Metals and Inorganics		
Ink Sludges		
Oils (used)		
Pesticides		
Preserving Agents		
Solvents/ Degreasers		
Spent Plating Wastes		

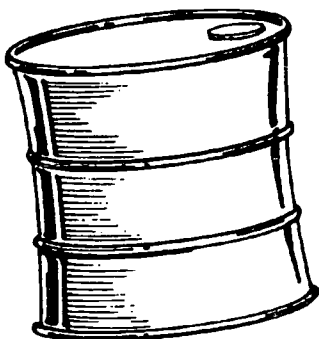
Handling Hazardous Waste ... Safely.



Reduction
Some manufacturing processes can be changed to reduce the amount of hazardous waste generated.



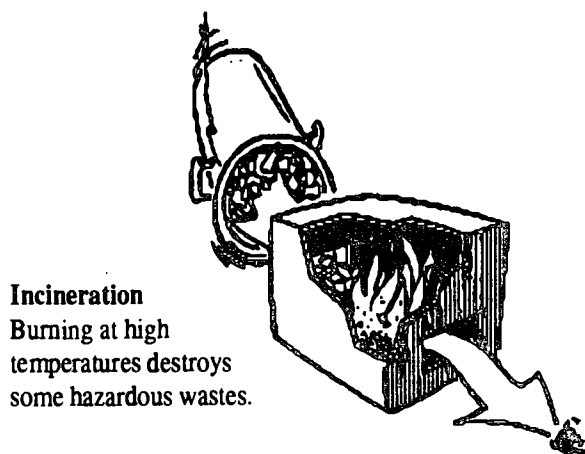
Bioremediation
Microscopic organisms, known as "bugs," consume the hazardous waste material.



Recycling
Some hazardous wastes can be reused to make other useful products.



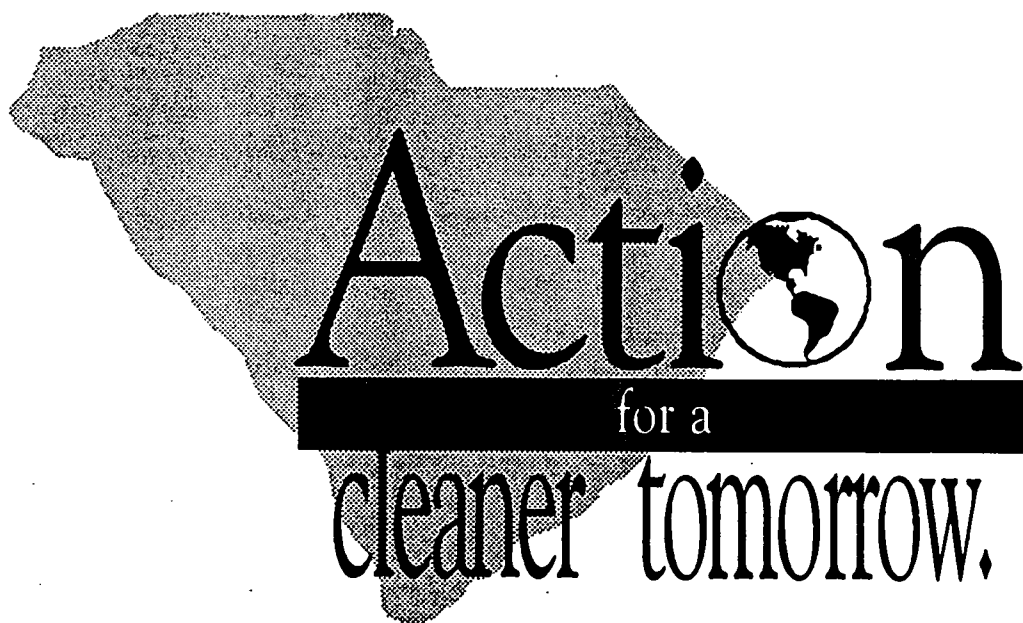
Chemical Treatment
Certain hazardous wastes can be made less hazardous by specially treating them with chemicals.



Incineration
Burning at high temperatures destroys some hazardous wastes.



Landfilling
After hazardous wastes have been treated, they can be safely buried in special landfills.



A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Signs of the Times

6.1.6.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Hazardous awareness and identification

Subject: Language Arts, Social Studies

Materials: See list below

Teaching Time: One to two class periods

Vocabulary: Hazardous materials, DOT, placard, nonverbal communication

Learning Objective

Students will:

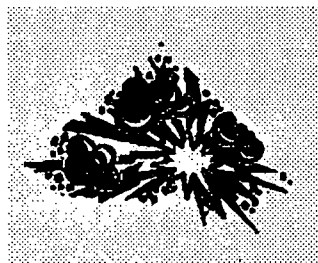
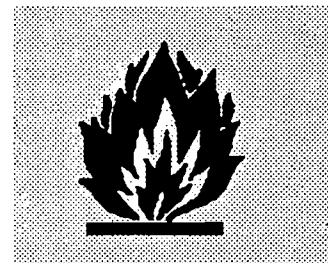
- demonstrate a knowledge of how design and color are used as symbols for things, places or ideas
- apply the knowledge of symbol language to hazardous material identification placards
- synthesize the information by writing a short narrative
- compare and contrast a written narrative to placard symbols.

Background

In the United States, **hazardous materials** are transported daily by trucks and trains. Often citizens are not aware that these materials are being moved through their communities until an accident occurs.

The packaging and transporting of hazardous materials are regulated. Each truck carrying these materials is required to display a **placard** describing the category of the hazardous material it is carrying and, sometimes, the specific material.

Placards used for this purpose must comply with United States Department of Transportation (DOT) design and color regulations. The use of design and



color to communicate a message or idea is called "symbol language"—one form of **nonverbal communication**. The purpose of this activity is for students to heighten their awareness of symbol language and have them apply that knowledge to the use of design and color in hazardous materials placards displayed on trucks.

Materials

Samples of logos and symbols, colored pencils, crayons, or markers (red, orange, yellow, blue, and green); student sheets. *Optional:* Hazardous Materials Product Kit, available from J.J. Keller & Associates, Inc., P.O. Box 368, Neenak, WI 54956-0368

Procedure

1. Ask the students to identify designs or logos that are used as symbols to represent businesses in their community. (For example, McDonalds, Ford, Coke or Pepsi.) Students might think of other symbols that represent restaurants, clothing and car manufacturers, or food products.



United States' industries annually generate nearly two tons of toxic waste for every man, woman and child in America.

Source: *50 More Things You Can Do To Save The Earth*

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2. Ask the students to name frequently used designs that represent ideas, as opposed to companies or products. Students might think of designs used for highways, traffic signals, countries, churches, political parties, holidays, or seasons.

3. Have the students develop associations related to the symbols until they become sentences and fully developed ideas, if possible. Each time the class determines the “message,” follow the answers with, “And what does that mean to you?” To demonstrate an example, draw a snowflake on the board as a symbol representing “snow.” Snow means cold, winter, no school.

4. Explain to the students that a design can be used as a symbol, as can color.

Ask the students how the color “green” is used as a symbol, what it means and what associations are made with that symbol. For example, a green traffic light means go; green highway signs mean cities or exits; green can symbolize a season (*spring or summer*) or a holiday (*St. Patrick’s Day*).

5. Explain to the students that symbol language is one form of nonverbal communication (*communicating a message without using words*).

6. Give each student a copy of the student sheet *Symbols: Hazardous Materials*, included. **Ask:** Has anyone seen these symbols before? Where? Why are some materials required to carry these labels? Why are symbols used to represent these categories of hazardous materials?

A. Give each student a copy of the student sheet *Placards and Labels: Hazardous Materials*, included. **Ask:** What does “placard” mean? (*A placard is a poster used to display a message.*) Note the colors assigned by the United States Department of Transportation (DOT). **Ask:** What reasons might the DOT have for assigning those specific colors to the symbols?

B. Ask the students to examine the placards/labels on the handout. Explain that the numbers at the bottom represent a hazardous

chemical classification system. The United Nations’ Hazard Class Numbers are displayed at the bottom of the placards. The number may be used in place of the written names of the hazardous chemical classes:

- 2 Gases
- 3 Flammable liquids
- 4 Flammable solids
 - Spontaneously combustible
 - Dangerous when wet
- 5.1 Oxidizers
- 5.2 Organic peroxides
- 6 Poisonous
- 7 Radioactive
- 8 Corrosive

Compare the placards for flammable gases and nonflammable gases. **Ask:** How do colors relate to traffic lights?

7. Have the students complete the following assignment.

A. Use crayons, markers, or colored pencils to color the placards according to regulations.

B. Each student should choose a placard on the handout and write a brief narrative about the contents of a truck or a train that is transporting hazardous material. Without revealing the design, color words, or numbers on the placard displayed by the transporter, the narrative should describe the contents in such a way that another person could use its clues to identify which placard was on the vehicle.

C. Have the students exchange narratives. Using the clues in the narrative and referring to the handout about placards, students are then to identify the placard that would be on the transporter.

Questions for the Class

1. Define nonverbal communication.
2. Name two elements of symbol language and give an example of each.
3. What elements of symbol language are used to identify hazardous materials that are being transported?
4. What symbols are used for the four major categories of hazardous materials?
5. Why it is important for people to understand the messages of the placards on vehicles transporting hazardous materials?
6. How could you help others become familiar with these symbols?

Extension Activities

1. Divide the class into four teams. Each team is to document the sighting of as many hazardous materials placards or labels as possible within a given geographic location. The sighting documentation must include date, time, and location of the sighting, plus a description of the placard color and number.
2. Assign each team a color and have cards corresponding to each color. Have team members write down their sightings, one to a card, and place them — one card at a time and one team at a time — in order on the Bingo board (included). The first team to get five in a row wins.

HAZARDOUS LABELS: TERMINOLOGY**Category**

Toxic

Placard Terminology

Poison

Definition

Causes illness, injury or death

Poison Gas

A gaseous substance that causes illness, injury or death

Irritant

Causes swelling, soreness or roughness

Chlorine

A highly irritating gas

Reactive

Combustible

Capable of igniting and burning

Dangerous when wet

Reacts violently with water

Oxygen

A gas required for combustion

Oxidize

May ignite other combustible materials

Organic Peroxide

An oxidizer that may explode at low temperature

Explosive

Capable of exploding at standard temperature and pressure

Ignitable

Flammable Liquid

A liquid that is capable of burning rapidly

Flammable Solid

A solid material that is capable of burning rapidly

Flammable Gas

A gaseous substance that is capable of burning rapidly

Corrosive

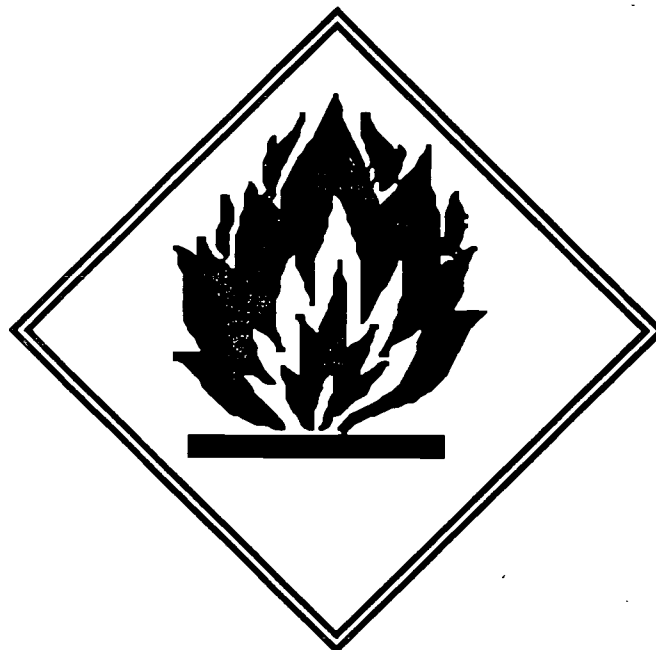
Corrosive

The pH level is below 2 or above 12.5; capable of causing materials — metals especially — to break down or dissolve

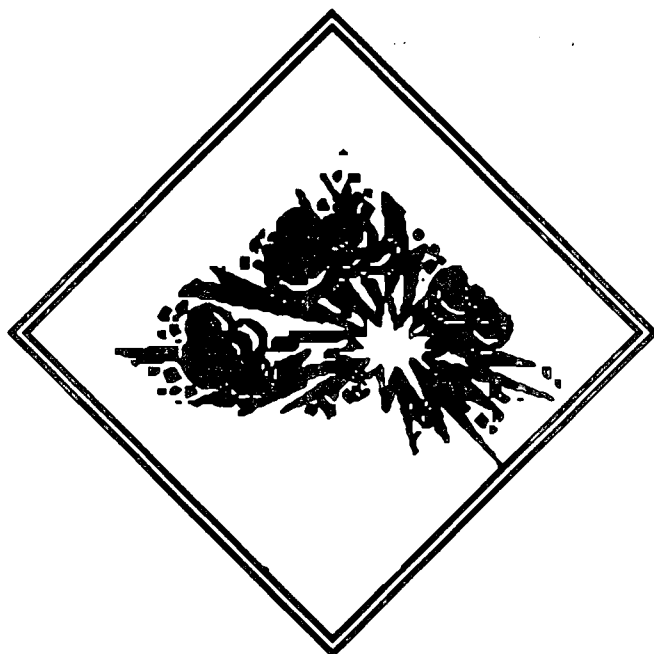
Symbols



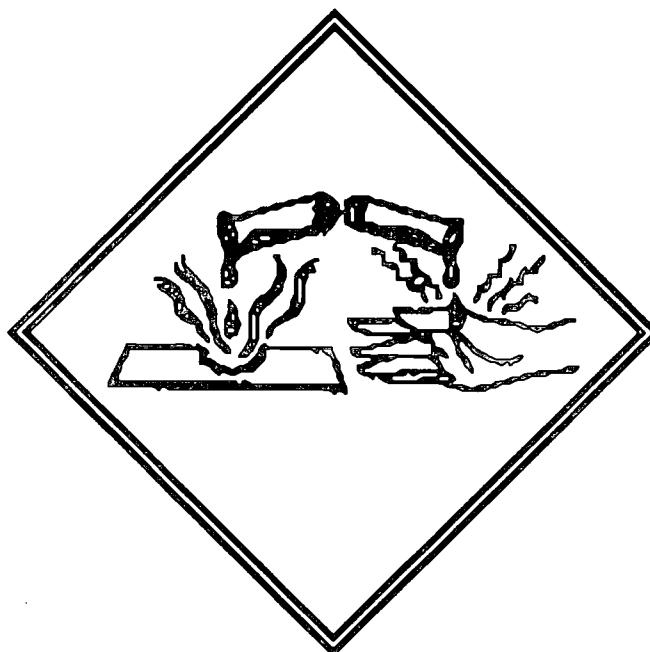
Poison



Flammable

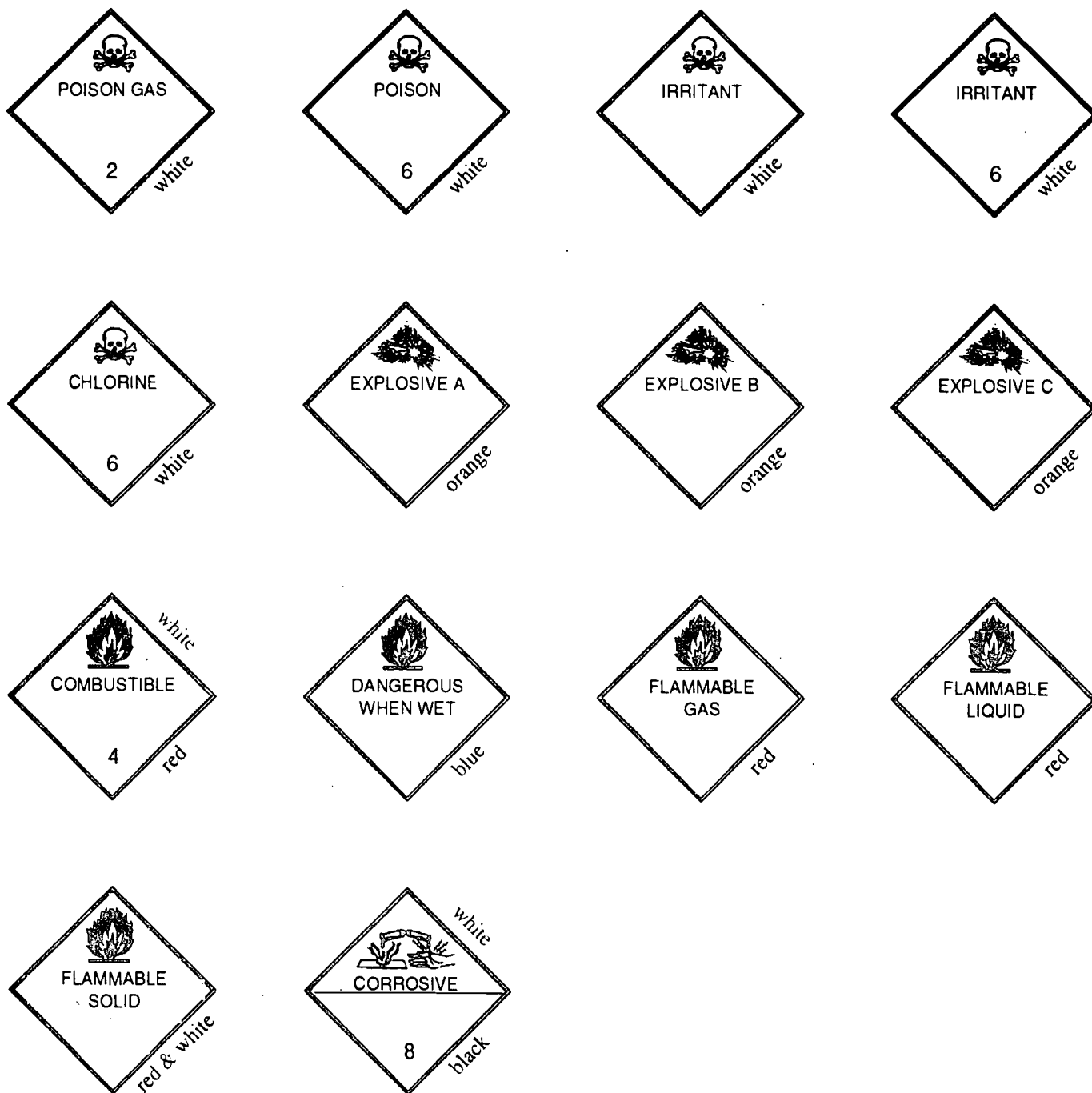


Explosive



Corrosive

Placards and Labels: Hazardous Materials

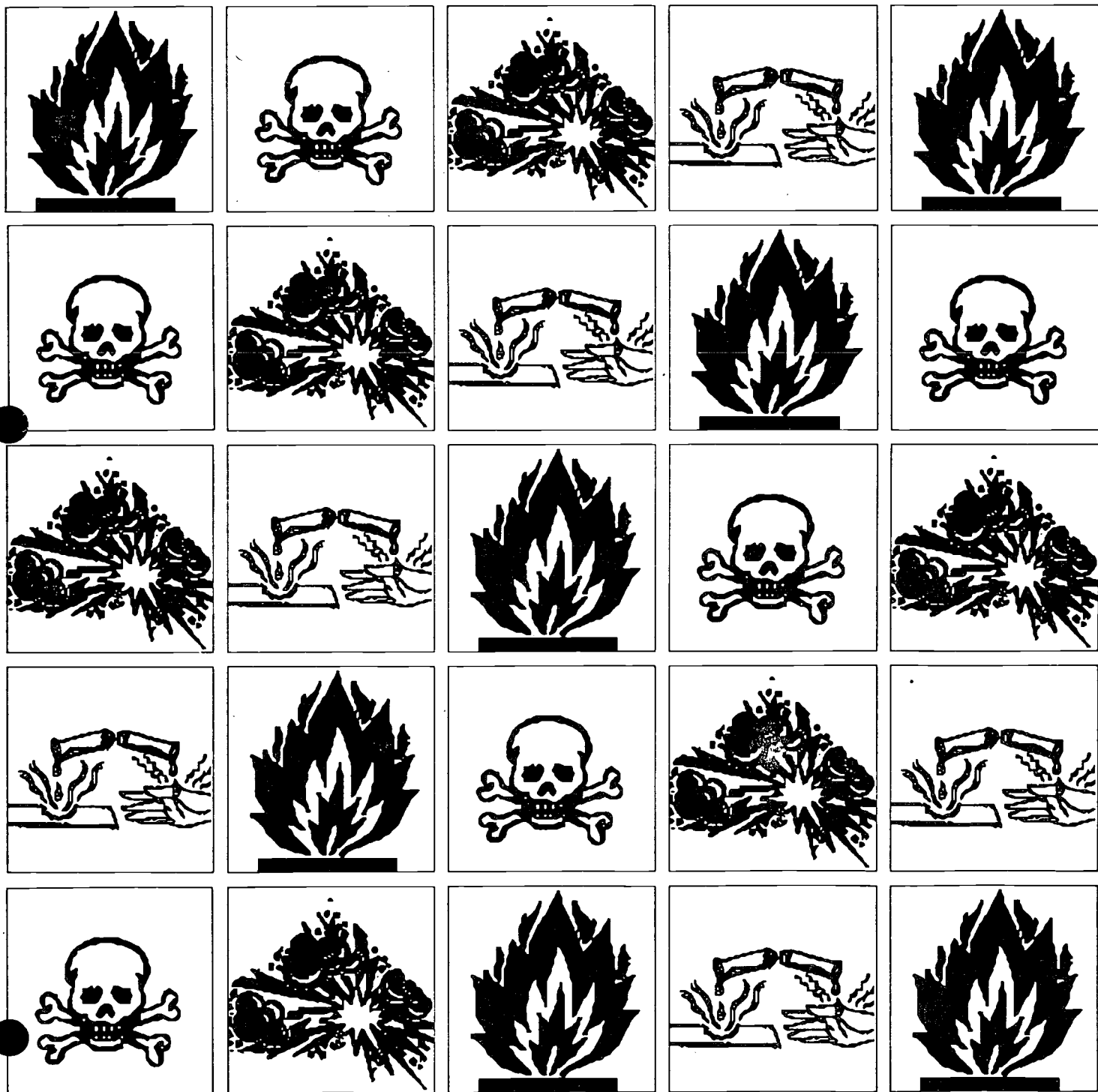


Note: These Placards and Labels are some of the most common identifiers of hazardous materials. There are many others and the list changes as materials are added.

Signs of the Times

Bingo

When you spot one of these Hazardous Waste Truck Placards, make a note of the type of placard, time, date, and location. Write it on your team's card and place it over the type of placard you saw. The first team to get five in a row wins!



TANK PLACARDS: IDENTIFICATION NUMBERS

<u>Identification Number</u>	<u>Chemical Name</u>	<u>Placard Symbols</u>
1001	Acetylene	Flammable Gas
1005	Anhydrous Ammonia, Liquefied	Nonflammable Gas
1008	Boron Trifluoride	Nonflammable Gas
1017	Chlorine	Chlorine
1036	Mono Ethylamine	Flammable
1046	Helium or Helium Compressed	Nonflammable Gas
1049	Hydrogen or Hydrogen Compressed	Flammable Gas
1050	Hydrogen Chloride	Nonflammable Gas
1072	Oxygen or Oxygen Compressed	Nonflammable Gas
1073	Oxygen, Refrigerated Liquid	Oxygen
1075	Liquefied Petroleum Gas	Flammable Gas
1078	Refrigerant Gas, N.O.S.	Nonflammable Gas
1090	Acetone	Flammable
1114	Benzene	Flammable
1133	Cement Liquid, N.O.S.	Flammable
1142	Compound Removing Liquid	Flammable
1170	Ethyl Alcohol	Flammable
1203	Gasoline, Gasohol, or Motor Fuel, N.O.S.	Flammable
1230	Methyl Alcohol	Flammable
1247	Methyl Methacrylate (Monomer)	Flammable
1255	Petroleum Naphtha	Flammable
1263	Paint, Shellac, Thinner, or Varnish	Combustible
1267	Crude Oil Petroleum	Flammable
1270	Oil, N.O.S. or Petroleum Oil	Combustible
1719	Alkaline Liquid, N.O.S.	Corrosive
1760	Numerous Corrosive Chemicals	Corrosive
1789	Hydrochloric or Muriatic Acid	Corrosive
1790	Fluoric or Hydrofluoric Acid Solution	Corrosive
1791	Hypochlorite Solution	Corrosive
1805	Phosphoric Acid Solution	Corrosive
1814	Potassium Hydroxide Liquid or Solution	Corrosive
1824	Sodium Hydroxide Liquid or Solution	Corrosive
1830	Sulfuric Acid	Corrosive
1831	Oleum	Corrosive
1832	Sulfuric Acid, Spent	Corrosive
1840	Zinc Chloride Solution	Corrosive
1863	Fuel, Aviation, Turbine Engine	Combustible
1866	Resin Solution	Flammable
1917	Ethyl Acrylate, Inhibited	Flammable
1962	Ethylene	Flammable Gas
1966	Hydrogen, Refrigerated Liquid	Flammable Gas
1977	Nitrogen, Refrigerated Liquid	Nonflammable Gas
1993	Flammable Liquid, N.O.S.	Flammable
1993	Combustible Liquid, N.O.S.	Combustible
1999	Tar Liquid, Asphalt, Cut Back	Flammable
1999	Tar Liquid, Asphalt, Cut Back	Combustible
2031	Nitric Acid (Over 40%)	Oxidizer
2055	Styrene Monomer, Inhibited	Flammable
2067	Ammonium Nitrate Fertilizer	Oxidizer
2187	Carbon Dioxide Liquefied	Nonflammable Gas
2209	Formaldehyde Solution (Formalin)	Combustible
2218	Acrylic Acid	Corrosive
2426	Ammonium Nitrate Solution	Oxidizer
2582	Ferric Chloride Solution	Corrosive
2789	Acetic Acid, Glacial	Corrosive
2790	Acetic Acid (Aqueous Solution)	Corrosive

Making Hazardous Waste Decisions

6.1.10.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Improper disposal of hazardous waste is harmful to the environment

Subject: English, Drama, Social Studies

Materials: Handouts included with lesson

Teaching Time: One class period, outside class research (optional)

Vocabulary: Hazardous waste



There are no federal laws regulating household hazardous waste. Education is the most effective means of ensuring that people use and dispose of products safely.

Learning Objective

Students will:

- examine common disposal practices
- gain an appreciation of better disposal options.

Background

Hazardous waste is waste that may pose a threat to human health or the environment. The disposal, transportation and handling of hazardous waste is regulated by federal law. However, many of the materials found in every day household products are considered to be hazardous substances and, when they are thrown away in the household garbage, are then considered to be household hazardous waste. For more information on hazardous materials, see the lesson entitled *Hazardous Waste in My Home Town* and the Resource section.

Learning Procedure

1. Distribute handouts: *Where Does It Go?*, *Where Should It Go?* and *What About All Those Household Products?*

Discuss the information and have the students list some hazardous products they have in their homes.

2. Tell the students they are going to role play the decision-making process for dealing with some common household hazardous substances. Remind students that there are many different views on what to do with hazardous wastes. Divide the class into three groups and assign each a different scenario. Use the Character Cards with this lesson to assign roles. As an option, you may make the character assignments ahead of time and have the students provide costumes and props to support their roles. For example, in Scenario #1, the character, Lt. John Jones of the local fire department could wear a firefighter's hat and a rain coat, and carry a hose. You may want to award extra credit points for students who "get into character."



In household hazardous waste collection programs in the United States, each household contributes an average of 100 pounds (45 kilograms) of these materials.

Source: Dana Duxbury, president of a national clearinghouse on household waste.

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SCENARIO #1: Sally discovers a can of gasoline in her garage. What should she do with it?

SCENARIO #2: A group of neighbors is setting up a community gardening project. They have purchased the plot of ground and are meeting to make some decisions about how the garden will run.

SCENARIO #3: Nine individuals have decided to combine their talents to create the Zippy Cleaning Service. As a group they need to decide what products they will use.

3. Each student should get one card listing a possible reaction to the question and/or issue raised in their scenario. They must represent that point of view in a group discussion on how the situation should be handled. Point out to the students that there is not necessarily one correct answer to these problems. These are current situations for which the state — and society at large — are trying to find a good solution.

4. Allow 30 minutes for discussion, at which time each group should make a recommendation concerning their particular dilemma. Have an assigned reporter keep track of the discussion (on the attached Decision Sheet) to tell the class what factors were considered prior to achieving a consensus.

Extension Activities

1. After completing one set of scenarios, allow the groups to discuss the other scenarios. Compare the final recommendations and the decisions made to reach those conclusions. How did they differ?

2. Have the students write an essay on how they would respond to one of the three scenarios.

3. Ask students to take the handout *What About All Those Household Products?* and share it with their parents.

4. Have the students make a diagram of their homes indicating all avenues for disposal of household hazardous materials and where the material goes.

Did You Know ...

- About 2 to 4 percent of all wastes generated in the United States are hazardous.
- Never throw household hazardous waste in the garbage or down the drain.
- Store hazardous materials in a cool, dry place, out of children's reach; and keep them in their original containers to avoid misuse.
- Do not mix hazardous materials.
- Use safe alternatives whenever possible.
- If you have a question about proper disposal, call S.C. DHEC's Office of Solid Waste Reduction and Recycling Hot Line at 1-800-76 USE IT.

This should trace, for example, the route of materials poured down the kitchen sink from septic tank to leach field or, when pumped, to a treatment facility, etc.

5. Write for more information on hazardous wastes. National Solid Waste Management Association
1730 Rhode Island Avenue, NW
Suite 1000
Washington, D.C. 20036
(202) 659-4613

Just Do It

Conduct a hazardous waste inventory of your home.

Replace as many of these products with non-hazardous substitutes as you can.

Where *Does* It Go?

When you wash your clothes in sudsy detergent, where does it go? When you clean your sink with cleanser, where does it go? When you pour a waste into the street drain, where does it go? It doesn't disappear; it all goes somewhere.

All the drains in your house lead from the bathroom, kitchen, and laundry room down to one large drain. If you live in the country, the watery wastes pass into a septic tank. A septic tank is a large underground concrete container. Wastewater spends two or three days there. Solids settle to the bottom of the tank. Liquids are piped into a drainfield which allows them to seep slowly into the soil. This soil sludge must be pumped out approximately every five years. It is then taken to a sewage treatment plant.

If you do not have a septic tank, then your wastewater is piped from your house to the sewage treatment plant. Underground pipes mix the liquids from homes, stores, businesses, and factories. At the sewage plant, wastewater is treated with bacteria. This can remove a majority of the harmful materials. Then the waste is diluted with water and discharged into nearby lakes or streams. All water discharged is required to meet state and federal purity standards and is monitored and tested frequently.

Pouring wastes into storm drains is wrong. They lead directly to waterways. Many chemicals and other wastes such as oil are dangerous, they can harm fish, or poison humans who eat the fish or drink the water.

Dumping wastes on the ground pollutes the soil. As the poison seeps into the soil, groundwater supplies may be ruined.

Burning toxic wastes in the backyard is not a good idea either. Harmful gases contaminate the air. Aerosol cans will explode.

There are two good solutions to toxic wastes. Buy and use as few hazardous materials around your home as possible. Then dispose of any leftover hazardous materials at a Toxic Cleanup Day, or according to disposal directions on the label.

Where *Should* It Go?

How do you dispose of items you do not need? It is preferable to buy any hazardous product in only the quantity you need and can use, but when you do need to dispose of a hazardous product, do it responsibly. Here are some alternatives to disposing of these items in your household garbage can. Never put hazardous substances in your garbage can.

Down The Drain With Lots of Water

powder cleaners
window cleaner
toilet cleaner
bleach

Evaporate Small Amounts Outside, Away From Children and Pets. Then Throw the Residue in the Garbage Can

latex paint (Large quantities of leftover latex paint can be donated to a local charity.)

Take To A Household Hazardous Waste Collection Site

pool cleaning agents
drain cleaner
silver polish
flea powder
kerosene
auto antifreeze
mothballs
spot removers
household insecticides
rat poison
paint stripper

Recycle

car batteries



Problem Solving Exercises

Scenario #1 Character Cards: Sally's Can of Gasoline

Scenario #1

You are Sally's neighbor, Nancy Nextdoor. You know that gasoline evaporates. Maybe Sally should just let the gas evaporate. But you know the fumes are a dangerous poison. There are small children in the neighborhood, and you wonder if evaporation might cause some air pollution.

Scenario # 1

You are Lt. John Jones of the local fire department. It is very dangerous to store gasoline. It is a fire hazard.

Scenario #1

You are Sally's brother-in-law, Fred. You tell Sally that gasoline is an effective weed killer. Sally has a large patch of blackberries in the corner of her lot. Maybe she should throw the gasoline on the ground around the berries.

Scenario # 1

You are Joe Cleandrain from the sewage treatment plant. You tell Sally that it is against regulations to pour gasoline down the sink, sewer, or storm drains.

Scenario #1

You are Pat, Sally's neighbor. You know that gasoline is a solvent. How could Sally use a solvent? You suggest that Sally check with a recycling center that takes solvents. But, the only one you know of is 25 miles (40 km) away, clear on the other side of the county.

Scenario #1

You are Chris, Sally's son's friend from school. You say that your dad has always poured his excess gas down the storm drain in front of the house. It is such a small quantity that it can't possibly hurt anything.

Scenario #1

You are Peter Putrescible, a representative of the community landfill. You tell Sally that the landfill will not accept flammable materials.

Scenario #1

You are Sally. You discovered a can of gasoline in your garage while you were cleaning. You don't know exactly how long it has been there. Because you are worried it may have water, oil, or rust in it, you have decided not to use it in your lawnmower.

Scenario #1

You are Sally's son, Ralph. Another friend of yours says that his dad is glad when he has excess gasoline around. He uses it to start the backyard grill.

Problem Solving Exercises

Scenario #2 Character Cards: The Community Garden

Scenario #2

You are Bob Tool. You own the Valley Hardware & Garden Store. You know that Metaldehyde is the active ingredient in slug baits. It was first discovered in 1936 and has been around for a long time.

Scenario #2

You are Sally Street. You have used salt on the slugs in your own garden. Last year you used saucers of beer to get rid of them. Although it worked pretty well, the saucers had to be changed often and sometimes it seemed like too much work.

Scenario #2

You are Sandy Beach. You read in a gardening magazine that kelp or seaweed laid around the edges of the garden would get rid of slugs. They crawl over the salty surface of the seaweed and the salt causes them to dry out and die.

Scenario #2

You are Polly Puregard. You checked with the Community Garden Association. They don't allow any chemicals in their community gardens. If this project allows chemicals, you don't want to participate.

Scenario #2

You are Ned Punchly. You suggest that boards be laid around each bed. The slugs will crawl under them during the day and someone can turn the boards over to collect or kill them. Or the group could elect a member to go out at night with a flashlight and collect them.

Scenario #2

You are Susan Feathers. You recommend the group build two fences; one right around the garden and another 2 or 3 feet (approx. 1 meter) away from the first. The group could put ducks and geese in this enclosed area. They would eat the slugs before they could get into the garden.

Scenario #2

You are Rita Byeby. You recommend planting sacrificial rows of bok choy, lettuce, cabbage, or other vegetables, all around the perimeter of the garden. These vegetables will keep the slugs busy and they will never get into the "real" garden.

Scenario #2

You are Dudley Duread. You read the label from a slug bait container and know that it is toxic to pets. Some pets have been poisoned by accidentally eating it in the garden. You also discovered that you are supposed to keep it away from the edible parts of the vegetables. What does this mean?

Scenario #2

You are John Goodgardner, who has tried for years to garden with a minimum of chemical pesticides and fertilizers. But last year the slugs got your lettuce, a real disappointment. You want the project to work and everyone to accept the decisions the group makes.

Problem Solving Exercises

Scenario #3 Character Cards: The Zippy Cleaning Service

Scenario #3

You are Annie Aerosol and are very concerned about aerosol cleaners. You know they are popular but not very cost efficient. Small droplets can land on other objects besides those being cleaned and some propellants can damage the ozone layer around the earth. Disposal of aerosol cans also creates problems because they may explode if they get too warm.

Scenario #3

You are Priscilla Polish and have been looking into the amount of hydrocarbons, petroleum distillates, and naphthas in polishes and cleaners. You have found that they can cause skin rashes, as well as eye, nose, throat, and lung irritation. They are also hazardous when ingested. Repeated exposure can result in liver and kidney damage.

Scenario #3

You are Granny Smith and have researched some alternatives to conventional cleaners. For example, several teaspoons of vinegar in water works well for cleaning glass and marble. Baking soda is recommended for items that are particularly greasy, such as pots, chrome, and tile.

Scenario #3

You are Tom Smellnice and are concerned about disinfectants and deodorizers that end up down the drain or in the air after they are used. You realize that these products do not create a germ-free environment anyway. You also wonder about toilet bowl cleaners that are flushed into the sewer or septic tank. Does this create a problem?

Scenario #3

You are Carl Caustic and are concerned about alkalies found in dishwashing and laundry detergents, and oven and drain cleaners. Swallowing these can cause severe stomach pains and burns in the mouth and throat. Inhalation can cause severe coughing and burns to the throat and lungs. Skin and eye contact can cause burns and damage to the cornea.

Scenario #3

You are Bob Bleach and have researched alternatives to commercial disinfectants. You have found that 1/4-cup (59 ml) of bleach in 1 quart (0.9 L) of water works well for cleaning many surfaces including counter tops, floors, toilet bowls, and bathtubs.

Scenario #3

You are Jack Cleanwater and are concerned about the phosphates in detergents, as well as the cleaning agent, TSP. You heard that phosphates can threaten the health of lakes, rivers, and streams by encouraging algae growth.

Scenario #3

You are Cloris Toxgas and are concerned with the human health hazards of chlorine. It is the basic ingredient of some bleaches and drain cleaners, and can cause burns and surface damage to eyes. If mixed with an acid or ammonia, a highly toxic gas is produced. Inhalation is especially dangerous to those with lung problems and can result in death.

Scenario #3

You are Lisa Lemon and have researched some alternatives to commercial furniture polishes and recommend:

1 teaspoon lemon oil

1 pint mineral oil

or equal parts of:

turpentine, boiled

linseed oil, and vinegar, plus a few drops of lemon oil for fragrance.

Problem Solving Exercises

Decision Sheet

Which Scenario? _____

Students in the group: _____

After each person in the group contributes information and the entire problem unfolds, what do you see as the ISSUES in this exercise? _____

Possible Solution: _____

What are some trade-offs to this solution?

What environmental, or human health *effects* could result from this solution?

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Possible Solution: _____

What are some trade-offs to this solution?

What environmental, or human health *effects* could result from this solution?

Final Decision: _____

Was the entire group satisfied with the decision? If not, why? _____

Note any COMMENTS and QUESTIONS that your group had during the decision-making process. Discuss these with the rest of the class.

What About All Those Household Hazardous Products?

Product

Aerosol Spray

Health, beauty, and cleaning products

Health Effects

Aerosol products release into the air particles that can be inhaled into your lungs and absorbed into your bloodstream. A chemical that is harmless to external parts of the body may be extremely dangerous if inhaled as an aerosol mist. Aerosol spray products have been associated with headaches, nausea, shortness of breath, eye and throat irritations, skin rashes, burns, lung irritations, liver damage, and heart problems. Aerosol products will explode if they are exposed to heat, causing burns and serious injury.

What You Can Do

You can buy products in a non-aerosol form. Many products come in creams, solids, liquids, or pump sprays. They can save you money; aerosol products are more expensive. If you do use aerosol products, do not inhale the fumes! Do not expose certain aerosol containers to heat. Never throw empty aerosol containers into a fire.

Product

Chlorine Bleach

Health Effects

Chlorine bleach can irritate and burn your skin and eyes. The fumes from chlorine bleach irritate your eyes and nose. Never mix chlorine bleach with ammonia, toilet bowl cleaners, or other products to make a stronger cleaning solution; the chemicals in the products may not be compatible and could produce very dangerous gases. Look for labels warning against mixing products with other products.

What You Can Do

Handle chlorine bleach with care! Better yet, mix baking soda and water to make a good cleaning solution.

Product

Detergents

Health Effects

Non-phosphate detergents can be highly alkaline and cause skin and eye irritations. They are very dangerous if swallowed.

Phosphate detergents can pollute our water systems by causing the explosive growth of algae. The phosphate acts as a fertilizer.

What You Can Do

Reduce the use of detergents. Use soap or baking soda instead.

Product

Solvents (Substances that dissolve something else)

Paint thinners, furniture strippers, dry cleaning fluids, degreasers, turpentine, and nail polish removers

Health Effects

Most solvents dissolve skin oils, causing skin irritations and damage. Solvent vapors or splashing of the liquid into the eyes can cause severe damage. The absorbency that allows contact lenses to retain medication also allows them to retain strong vapors from solvents. Instead of being washed away quickly by tears, chemicals are then held against the eyes until the lenses are removed. Lengthy exposure can cause considerable eye damage or irritation. The breathing of solvents, which evaporate quickly and enter the air, can cause nose and throat irritations, can damage lung tissue, and can enter the bloodstream through the lungs. Repeated exposure to small amounts of some solvents can cause internal damage to the liver and kidneys, which are the first line of defense against unwanted chemicals in the blood.

What You Can Do

Use solvents with utmost care and respect. If possible, use solvents outdoors. When using indoors, have plenty of fresh air and good ventilation. Never transfer solvents to unlabeled containers — especially food/drink containers.

Product

Air Fresheners

Health Effects

Air fresheners may interfere with your natural sense of smell by coating nasal passages with an oily film or with a nerve-deadening agent. Air fresheners don't eliminate room odors; they simply introduce a new smell and mask the offensive odor.

What You Can Do

Use a box of baking soda in the refrigerator to remove odors, a dish of hot vinegar to remove room odors, or a bouquet of flowers or herbs to give the room a pleasant smell.

Product

Paints

Health Effects

Chemicals in paints can irritate your eyes, skin, and lungs. Fumes can cause headaches, nausea, respiratory problems, muscle weakness, and liver and kidney damage. Some paints are flammable.

What You Can Do

Paint items outdoors when possible. When you paint indoors, make certain you have adequate ventilation. Using latex paints eliminates the need to use paint thinners which contain additional hazardous chemicals.

Product**Hobby Materials****Glues & epoxies****Health Effects**

Glues and epoxies are flammable. They irritate the skin and lungs and can make you more sensitive to a number of other substances. Some people have died after deliberately inhaling fumes from these products.

What You Can Do

Read product labels carefully. Wear gloves when you use them, and make certain you have good ventilation. Store these products away from heat and children.

Product**Photography Supplies****Health Effects**

Dangerous chemicals used to develop photographs are methanol, xylol, methylene chloride, turpentine, benzene, acetates, and hydrochloric acid. Methylene chloride and benzene have been associated with causing cancer. Many of these chemicals are flammable and can cause skin, eye, and lung irritations; some contain acids which can burn and blind you.

What You Can Do

Use these materials only in a well-ventilated area. Wear goggles and gloves. Store these chemicals in unbreakable containers away from heat. Store acids in non-metal containers. Never mix water into acid; when necessary, add acid slowly to water. Avoid products that contain benzene.

Products**Rug and Upholstery Cleaners****Health Effects**

These cleaners may contain chemicals which, when inhaled, can cause nausea, anemia, liver damage, convulsions, and possibly coma.

What You Can Do

Wear gloves and have adequate ventilation during the cleaning process. Clean rugs and upholstery with a non-aerosol shampoo. Check labels and purchase less hazardous products.

A Trip to a Landfill

6.11.1.

Preparation Time:

Easy To Do

Moderate

Extensive

Grade: 6 – 8

Focus: Solid waste disposal in landfills

Subject: Social Studies, Science

Materials: This lesson is a field trip exercise

Teaching Time: One class period plus field trip

Vocabulary: Landfill, leachate, RCRA, Superfund

Learning Objective

Students will:

- see, first hand, how a landfill operates
- examine the differences between a dump and a modern, sanitary landfill.

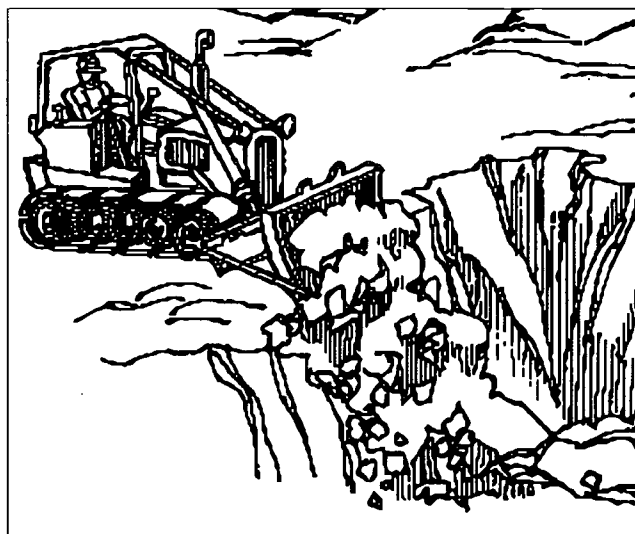
Background

For more information on landfills, see the Resource section.

In 1979 the U.S. Environmental Protection Agency issued landfill criteria that prohibited open dumping. According to the *Garbage Primer*, published by the League of Women Voters:

“Concern about ground water pollution and other negative impacts of landfilling waste led to public opposition to local dumps and prompted the transformation of dumps into modern, sanitary landfills. Instead of communities hauling their garbage to the local ravine, sand pile, or old quarry at low or no cost, they are hauling it to high-priced modern landfills designed to protect the environment and the public.

South Carolina has 39 municipal solid waste landfills and, according to the *1993 Information Please Environmental Almanac*, South Carolina landfills about 80 percent of all of its garbage. The



South Carolina Solid Waste Policy and Management Act of 1991 has banned many wastes from landfills. These wastes include yard trash, lead-acid batteries, whole waste tires, and used oil. White goods (refrigerators, stoves, etc.), are banned from South Carolina's landfills beginning in May 1994. According to the Department of Health and Environmental Control, about one-third of South Carolina's domestic waste permitted landfills will close in 1994.

The Act also requires the installation of scales at each municipal solid waste disposal facility and the keeping of records concerning all facets of solid waste management.

Stricter federal landfill standards under the Resource Conservation and Recovery Act (RCRA) have forced many small, local landfills to close. They have been replaced with larger local and regional landfills.

The reason landfilling garbage remains popular is that landfills are “cheaper to operate per ton of

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Only 16 percent of Japan's waste is disposed in landfills.

Source: Hershkowitz and Salerno

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waste than either incinerators or recycling plants,” according to the *1994 Information Please Environmental Almanac*. “The average price to landfill garbage, according to an April 1993 national survey of 3,000 landfills, was \$34.38 per ton. However, start-up costs for a landfill built to conform with federal rules effective (in the fall 1993) are becoming more expensive, costing as much as \$125 million.”

Beyond coming up with the millions of dollars necessary to build a landfill, communities are faced with difficult decision of where to put the landfill. “The siting of new landfills is hampered by the poor environmental track record of older dumps,” according to the *Garbage Primer*. “More than 20 percent of the 1,200 clean-up sites on the Superfund national priority list are garbage dumps.”

RCRA's Subtitle D restricts the siting of landfills in floodplains, wetlands, earthquake-prone areas, near airports, or where the ground cannot support the weight of a landfill. State and local governments can influence the selection of a site by requiring building permits, regulating the landfill size, and enforcing local zoning ordinances.

Modern landfills began as a hole dug in the ground. Today, sanitary landfills are lined with a layer of compacted soil, with a synthetic liner, or both. Garbage is dumped into this lined landfill cell and, at the end of each day, covered with a layer of soil or plastic. To ensure better pollution control, landfill regulations require that all new and expanded landfills be constructed with a liner, a leachate collection system (a system for collecting the fluids that seep through the garbage), a landfill gas control system (methane gas is generated in a landfill and collected through a system of pipes), and a ground water monitoring system. Subtitle D requires that when a landfill is full, it must be closed (capped with soil), monitored, and cared for for at least 30 years after closure.

According to the *Garbage Primer*, of the landfills in operation in the United States, fewer than 1,500 have ground water monitoring systems and only about 900 have liners.

Learning Procedure

1. Contact your regional Department of Health and Environmental Control Environmental Quality Control office to arrange a tour of the local landfill. You can find the list of regional offices included with this lesson and in the Resource section.

2. Review the Background material included with this lesson and this curriculum's Resource section on landfills with the class. Before the tour distribute (or prepare a transparency of) the graphic entitled *Layers of the Landfill* included with this lesson.

3. In preparation for their trip to the landfill, have students develop a list of questions to ask during the tour. As a class, consider questions in the following categories: technical, social, and regulatory. For example: technical questions may include:

- Design of the landfill. Is it lined? Does it have a leachate collection system? Ground water monitoring? Methane gas collection system? If so, what happens to the methane after it is collected? How many cells are there and how much trash is put into each cell? What do you use to cover the cells and how often? What kind of equipment do you use? What is the collection method? Is the waste compacted before it gets to the landfill? Where is this done?

Social questions may include:

- When was the landfill built? How was the site chosen? Was there any opposition to it being built here? How much time is left until this landfill is full? How much trash do you get each day? How many people work here? What are their jobs? How much does it cost to run a landfill? Are there plans to build a new landfill? When? Where? How much will it cost? Who will pay for this? Is there a charge to put garbage here? How much? What geographic area does the landfill serve?

Regulatory questions may include:

- Do you weigh the garbage before it is put into the landfill? How do you keep banned items, such as old tires, lead-acid batteries, yard wastes, and white goods, from being disposed in the landfill? Are there any local ordinances that affect

**South Carolina Department of Environmental Control
Bureau of Solid Waste and Hazardous Waste Management
Division of Solid Waste Management
Environmental Quality Control District Offices**

Appalachia I District - EQC
2404 N. Main Street
Anderson, S.C. 29621
(803) 260-5569, Fax 260-4855

Lower Savannah District - EQC
218 Beaufort Street, NE
Aiken, S.C. 29801
(803) 641-7670, Fax 641-7675

Appalachia II District - EQC
301 University Ridge, Suite 5800
Greenville, S.C. 29601
(803) 241-1090, Fax 241-1092

Pee Dee District - EQC
145 E. Cheves Street
Florence, S.C. 29506
(803) 661-4825, Fax 661-4858

Appalachia III District - EQC
P O Box 8778
975-C North Church Street
Spartanburg, S.C. 29303
(803) 596-3800, Fax 596-2136

Trident District - EQC
2470 Air Park Road
North Charleston, S.C. 29418
(803) 740-1590, Fax 740-1595

Catawba District - EQC
2475 DHEC Road
Lancaster, S.C. 29720
Mailing Address: P O Box 100
Fort Lawn, S.C. 29714
(803) 285-7461, Fax 285-5594

Upper Savannah District - EQC
613 South Main Street
Greenwood, S.C. 29646
(803) 223-0333, Fax 223-6935

Central Midlands District - EQC
Building #5/PO Box 156
State Park, S.C. 29147
(803) 935-7015, Fax 935-6724

Waccamaw District - EQC
1705 Oak Street Plaza/Suite #2
Myrtle Beach, S.C. 29577
(803) 448-1902, Fax 946-9390

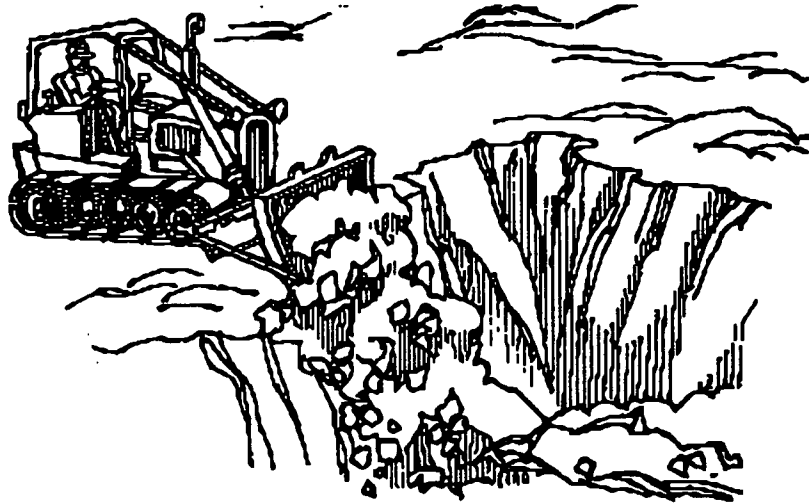
Low Country District - EQC
1313 Thirteenth Street
Port Royal, S.C. 29935
(803) 522-9097, Fax 522-8463

Wateree District - EQC
105 Magnolia Street
Sumter, S.C. 29151
(803) 778-1531 & (803) 778-6548, Fax 773-6366

Layers of the Landfill

Today's sanitary landfill is engineered to protect public health and the environment.

Subtitle D of the Resource Conservation and Recovery Act establishes standards that municipal landfills must meet. A Subtitle D Landfill is layered like this ➡



Top Cap - The top cap of a landfill must be covered with:

- 2 ft. (61cm) thick soil cover
- Drainage layer
- Flexible membrane layer of 60 mil HDPE plastic*
- 18 inches (45.7 cm) minimum clay liner (1×10^{-5} cm/sec max)
- Gas management layer

Waste Cells with operational cover

Bottom Liner - The landfill must have a protective bottom liner system that includes:

- 2 ft. (61cm) protective layer of soil
- Leachate collection system
- Flexible membrane liner (60 mil HDPE plastic*)
- 2 ft. (61cm) clay liner (1×10^{-7} cm/sec**)

South Carolina ...

- Landfills about 80 percent of its solid waste.
- Has 39 permitted municipal solid waste landfills.

* Other, similar materials may be substituted for HDPE.

** Refers to the permeability, or speed in which liquids can seep, of the clay. This number means that liquids seep very slowly or hardly at all.

Tin Can Incinerator

6.11.4.

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 – 8

Focus: Solid waste incineration

Subject: Science, Math

Materials: See list below

Teaching Time: One to two class periods

Vocabulary: Volume, ash, incineration

Learning Objective

Students will:

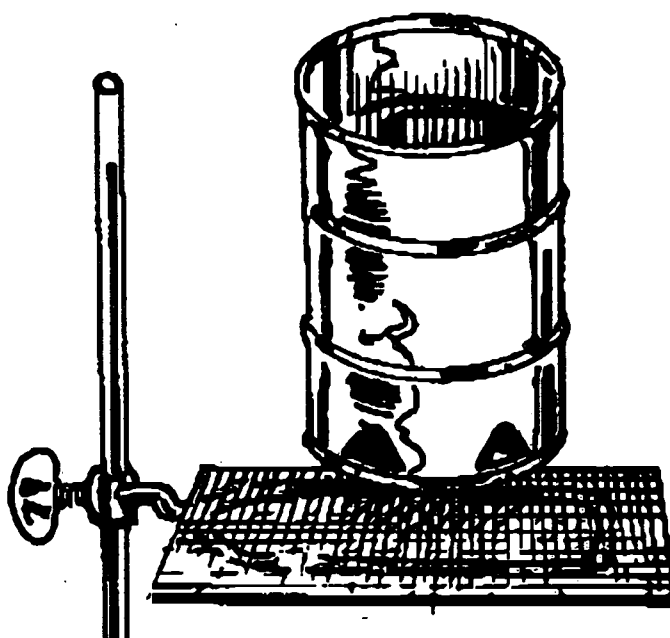
- calculate the reduction in weight and volume of solid waste from burning.

Background

This activity illustrates the volume and weight reduction possible through burning waste. It also illustrates that burning produces air emissions, *but does not simulate the operation of a state-of-the-art incinerator*. While backyard burning allows pollutants to escape into the atmosphere, today's incinerators capture about 99 percent of these emissions. Therefore, weight and volume reductions will be more dramatic in this experiment than in an incinerator. (See the Resource section for more information on Incineration.)

SAFETY NOTE TO TEACHERS:

1. Do not burn any types of plastics. It is impossible to tell what types of resins and/or additives are used in the hundreds of different plastic packaging. Many plastics such as PVC, polypropylene, or polystyrene produce toxins when burned.
2. Perform this experiment outside if your school does not have laboratory facilities for burning. Also it's a good idea to have a fire extinguisher or fire blanket handy.



Materials

- one-gallon metal can with several ventilation holes about one-inch from bottom. Use a punch-type can opener to make the holes
- a piece of metal screen large enough to cover the top of the can
- five pieces of cardboard, six-inches square
- masking tape OR us a pre-made box (like a shoe box) and measure the dimensions to calculate the volume
- enough solid waste to fill a box 6" x 6" x 6" (15 cm x 15 cm x 15 cm)
- materials that are easy to ignite such as paper, popsicle sticks, kindling, etc.
- matches
- ruler and balance
- marker
- safety goggles
- student work sheet (one per student)
- tongs

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South Carolina has an incineration rate of 5 percent. The District of Columbia has the the highest incineration rate at 59 percent.

Source: *The Information Please Environmental Almanac, 1994*

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Learning Procedure

1. Distribute student worksheets and explain that in this lesson they will be burning representative waste items to observe the effects of **incineration**. Tape cardboard pieces together to form a box with four sides and a bottom. Fill the box with the waste, and have students calculate the **volume**.

Volume of waste = length x width x height (depth)

Volume of waste = 6" x 6" x 6"

(15 cm x 15 cm x 15 cm)

Volume of waste = 216 cubic inches

(3,375 cubic cm)

If you are using a pre-made box (like a shoe box), measure and calculate the volume.

2. Transfer the waste from the cardboard box to the gallon can. **DO NOT BURN THE CARDBOARD BOX**. Light the materials and immediately cover the top of the can with the screen. Observe what comes out of the can while the materials are burning. Have students record their observations in the appropriate area on the worksheet for future discussion.

3. When burning is complete and the **ashes** have cooled, return the ashes to the cardboard box. Spread them evenly on the bottom of the box and measure the height (depth) of the ash layer. Using the same formulas above, calculate the volume of the ash. Now, calculate the difference in the volume occupied by the waste before and after burning.

Extension Activities

1. Try incinerating an equal volume of food scraps (orange or banana peels, egg shells, apple cores, etc. You may want to dry these out so they will burn more easily.) Which is easier to burn: the food scraps or the paper and wood products from the original experiment? Which would take longer to incinerate? Are the final by-products from both experiments the same?

2. The classroom experiment allowed some ash, heat, and other by-products of burning to escape into the atmosphere. However, incinerators are required by law to have precipitators to remove ash and toxics from air emissions. Research different methods of pollution control in incinerators. What happens to the ash that is collected after incineration is complete? (*South Carolina has two landfills specially designed to accept ash. These are called "ash monofills," and are the Sandy Pines landfill located in Dorchester County and Bees Ferry landfill in Charleston County.*)

Just Do It

Help stop backyard burning in your community. Write articles for your school paper educating students about how backyard burning pollutes our air.

Name _____ Date _____

Step 1. Crumple the pieces of paper and put them into the can, packing them together to fill up as much space as possible. Fill the can with paper until it is about half full.

Step 2. Calculate the volume of the paper in the can using the following formula: $V = \pi r^2 h$;
where $\pi = 3.14$, r = the radius of the can, h = the height of the paper in the can.

To find the height of the paper in the can, mark on the outside of the can with a marker the height of the paper, then measure with the ruler from the bottom of the can to the mark. Once you have completed your measurements, fill in the blanks below and perform the calculations. Your answer will be the volume of the paper and should be recorded on Chart #1. Show your work.

$$V = \pi r^2 h$$

$$V = 3.14 \times (r \times r) \times h$$

$$V = 3.14 \times (\text{_____} \times \text{_____}) \times \text{_____}$$

$$V = \text{_____}$$

Step 3. Weigh the can and the paper on the balance. Record the weight on chart #2.

Step 4. Fluff the paper so that it is not packed too tightly in the can. Be sure to fluff the paper all the way to the bottom so that oxygen can get to all of the paper or it will not burn completely.

Step 5. Carefully light the paper with a match. DO NOT PUT THE MATCH INTO THE CAN.

Step 6. Observe what comes out of the can while the materials are burning. Record this on Chart #3.

Step 7. When the can has cooled, use the tongs to move the can and its contents to the balance. Record its weight on Chart #2.

Step 8. Calculate the volume of the ashes. Remember to mark the outside of the height of the ashes on the outside of the can and measure from the bottom of the can to that point. Your answer will be the volume of the ash and should be recorded on Chart #1. Show your work.

$$V = \pi r^2 h$$

$$V = 3.14 \times (r \times r) \times h$$

$$V = 3.14 \times (\text{_____} \times \text{_____}) \times \text{_____}$$

$$V = \text{_____}$$

Step 9. Clean up your work area and follow your teacher's instructions for completing the charts and calculating the percent reduction in weight and volume of the waste.

Name _____ Date _____

Chart #1: Volume

A Volume of waste in can before burning $V = \pi r^2 h$	B Volume of ash in can after burning $V = \pi r^2 h$	C Difference in volumes (A-B)	D Divide C by A	E Multiply D x 100 (This is the (percent decrease in volume.)

Chart #2: Weight

F Weight of can and paper	G Weight of can and ashes	H Difference in weights (F-G)	I Divide H by F	J Multiply I x 100 (This is the (percent decrease in weight.)

Observations while burning: _____

Conclusions

From your observations and experiment, you should be able to make some conclusions about incineration and volume reduction of waste. What are your conclusions? Compare an open burning scenario, like the one you just completed, to that of a controlled incinerator where air emissions are monitored and most ash particles are removed. Compare and contrast the impact of open burning and incineration. Use a separate piece of paper.

Investigating Incineration

6.11.5.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Waste incineration

Subject: Science, Social Studies, Language Arts

Materials: Handouts included with this lesson, a bag of mixed trash (paper, plastic, glass, etc.)

Teaching Time: Two class periods, field trip

Vocabulary: Incineration, dioxin, ash, heavy metals, waste-to-energy, emission, toxic, hazardous waste

Learning Objective

Students will:

- consider the advantages and disadvantages of waste incineration.

Background

About 200 pounds (91 kg) of trash are generated each week by the average American family. More space is needed for waste disposal as landfills fill up and become more expensive and difficult to construct. **Incineration** is one possibility some experts consider.

Incineration reduces the volume of waste requiring disposal by 70 to 90 percent. In a **waste-to-energy** plant, burning waste can also generate electricity. At some incinerator sites, there is concern that **toxic** substances such as **dioxin** may be released into the air, creating air pollution and possible health hazards. Dust and noise pollution are other possible problems associated with incineration.

Incineration is most efficient when certain materials are separated out of the waste stream. Newspapers may raise the burning temperature too high for

U.S. EPA's Hierarchy of Waste Management Strategies

- Reduce waste by preventing its creation
- Recycle and compost as much waste as possible
- Incinerate waste or treat it in other ways to reduce its volume
- Landfilling waste is last in the list of options

efficient burning, and they pollute the **ash** with **heavy metals**. Metals and glass do not burn.

Because newspaper, steel, aluminum and glass are all recyclable, separating these materials from the waste stream prior to incineration contributes to resource conservation and efficient plant operation.

Although waste combustion is listed in the U.S. EPA's Integrated Waste Management strategy before landfilling, incineration is a waste management method that sparks controversy among scientists and citizens.

In South Carolina, incineration is not listed as a priority over landfilling. However, as counties develop their waste management plans, incineration is an option. Specifically, as stated in the 1992 South Carolina Solid Waste Management Plan, "With the increased cost of converting existing landfills and the high costs of siting and

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France was the first nation to impose a direct pollution tax that requires emitters to pay per unit of pollution discharged.

Source: 1993 Environmental Almanac

constructing new landfills to comply with the new federally mandated standards, it is essential to adopt the most effective volume reduction techniques. Each county/region must consider all options and must select the best available volume reduction methods for its integrated solid waste management program.

"Nearly 75 percent of the municipal solid waste stream is combustible. Therefore, combustion provides the greatest degree of volume reduction, 70 to 90 percent. A county/region with a large concentrated population should consider a waste-to-energy, or combustion system as part of the volume reduction efforts of its integrated solid waste program."

The pros and cons of incineration need to be weighed by people looking for solutions for solid waste disposal and pollution. There are no right or wrong answers, only informed opinions. For more information, see the incineration handout included with this lesson and the information in the Resource section.

Learning Procedure

1. Hold up the bag of mixed trash. Ask: Not know what's in this bag, do you think it would be better to incinerate it or bury it in a landfill? (Let students brainstorm their answers.) Have several students sort it for items that could be reused or recycled, removing them from the waste stream. Compare the amount left to the original sampling. Discuss the implications of incinerating or landfilling our natural resources versus recycling them.

2. Share the Background material in this lesson, the illustration of an incinerator, and in the Resource section in Incineration, and discuss with the students the pros and cons of incineration.

3. Give each student a copy of the handout material. Assign students to read the material and to prepare one of the following projects to be presented to the class:

- write and present to the class a 60-second television public service announcement

supporting/opposing incineration. (Let each student decide their own position) Draw one scene from the storyboard.

- create an informational poster on incineration

- research and write a list of 20 facts about incineration from at least two sources different from the handouts

- write a letter to your county waste management supervisor stating your opinion for or against incineration

- using the *Inner Workings of an Incinerator* illustration, invent a new technique for improving incineration. Write a paragraph about how your invention would work and how it will make the environment cleaner. (Students may draw a diagram of their invention.)

4. From the class discussion, develop a list of questions and write to a waste incineration plant operator. Questions could address treatment of ash, scrubber technology, and types and sources of waste incinerated. Call S.C. DHEC at 1-800-76-USE-IT for the location and address of South Carolina's incinerators.

Extension Activities

1. Take a field trip to a commercial incinerator.

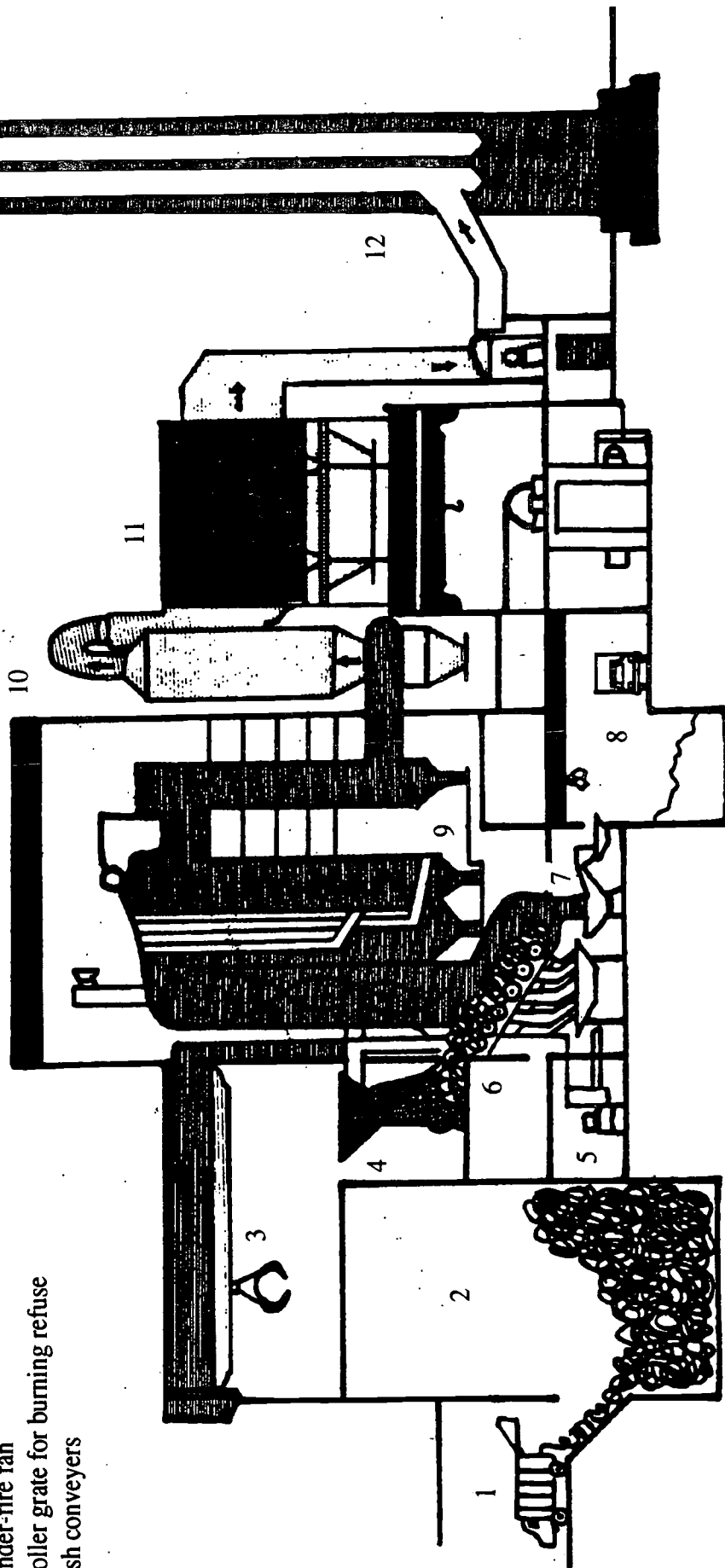
2. Construct a wall chart comparing the advantages and disadvantages of waste incineration.

Just Do It

Never burn wastes, including yard clippings and leaves, at home. Backyard burning does not have the pollution prevention technology needed to safely deal with trash.

The Inner-workings of an Incinerator

1. The tipping hall where garbage trucks enter
2. Refuse bunker where trucks put garbage
3. Refuse crane
4. Charging hopper sends waste to grate
5. Under-fire fan
6. Roller grate for burning refuse
7. Ash conveyers
8. Ash bunker and crane for collection and transport
9. Fly ash collection (first stage of air cleaning)
10. Scrubber to remove acid gases
11. Dust collector/filter
12. Stack (final stage of air cleaning)



The History of Incineration

The first municipal incinerator was designed and built in England more than a century ago. It seemed to be a simple, efficient and sanitary way to dispose of garbage. Burning garbage eliminated the need for transporting waste from cities, saved space in dumps and destroyed many disease-causing microorganisms and viruses. The technology was soon imported to this country, and by the 1920s there were more than 300 incinerators in use.

The first incinerators burned trash without worrying about what was coming out of their smokestacks. As concern rose over the quality of our air and legislation was introduced to prevent further air pollution, the cost of pollution control equipment made it cheaper to landfill waste and use of incinerators declined.

Technology was then developed to absorb some of the heat from waste incineration, turning water to steam which could then be used to generate electricity. This process lowered the temperature of incinerator exhaust to within temperatures where proven emission control equipment could operate effectively. This technology made it possible to install pollution control equipment in incinerators. An incinerator's ability to generate electric power helped offset some of the high cost of installing this emission scrubbing equipment. With landfills filling up, this new technology, called with varying degrees of precision "waste-to-energy," "energy recovery," and "resource recovery," led to a renewal in incinerator popularity in the 1970s.

Today's waste-to-energy incinerator plants can reduce up to 90 percent of the volume of waste needing to be disposed and can be designed to process from 100 to more than 3,000 tons of refuse daily. At the same time, they produce steam or electricity which can satisfy a portion of local energy needs.

How Do Incinerators Work?

Incinerators burn waste to reduce its volume; that is, to make it smaller. Incinerators can burn unprocessed waste (that is trucks just dump garbage into the tipping hall; this called "mass burn.") or processed waste (that garbage that has had materials that do not burn ... such as glass and metal ... removed; this is called "refuse-derived fuel"). Incinerators can be equipped to generate energy by using the heat from burning garbage to turn water to steam, which is then either fed into a steam-loop (sometimes called a district heating system) or used to turn turbines installed at the incinerator plant to generate electricity.

Mass-burn facilities appear convenient from a solid waste management perspective. There is no pre-processing of waste, and no changes must be made in the way most cities and towns collect their trash. When trucks enter a mass-burn facility, their loads are weighed, and the trash is delivered to a tipping platform. Front-end loaders and cranes are used to push the waste down a shoot (hopper), from where it is fed into the combustion chamber. The residual ash from the combustion chamber

(bottom ash) and ash collected by pollution control equipment (fly ash) is deposited into large covered dumpsters which are hauled away to a lined landfill.

Incinerators require a steady flow of waste and need to maintain a steady temperature in burning. Non-combustibles in the waste stream such as glass and metal inhibit efficient burning as do kitchen wastes, leaves, and grass because of their high moisture content (30-75 percent water) and low Btu (or heat released during combustion) value. Increasing amounts of petroleum-based plastic, with a high Btu value, in the waste stream also affect burning. To maintain a consistent temperature, incinerator operators must control the type of garbage, the amount of trash fed into the plant, how often the system is started up and shut down, and other variables that change burning temperatures.

What Are Some Of The Benefits Of Incinerators?

Incinerating solid waste can reduce the volume of trash going to a landfill by up to 90 percent, resulting in a 60 to 70 percent reduction overall in landfill demand. And that means that landfills do not fill up as fast. By doing, this incineration helps conserve land and protect water sources from contamination.

Incineration also destroys potentially disease-causing organisms in solid waste and helps keep them out of landfills. Incineration also destroys a number of chemicals and toxic compounds, such as pesticides, that are a major source of contamination at existing landfills. Dioxins are both created and destroyed in the incinerator combustion process, and some data indicate that resulting dioxin levels may be reduced overall from that found in incoming solid waste.

In waste-to-energy plants, heat from the combustion process is used to make electricity. While the sale of this electricity is not enough to pay for the incinerator, it does help defray some of the expense.

In many countries, incineration is the primary waste disposal solution. In Japan, where about 50 percent of waste is recycled, 34 percent is incinerated. Incineration is beneficial because Japan has a growing population and very little land available for landfills. In the past 25 years, Japan has build more than 1,900 incinerators and many of these are waste-to-energy facilities ... burning garbage and making electricity.

What Are Some Of The Problems Of Incinerators?

Incinerators share many of the problems of any waste management facility such as landfills and recycling centers. These shared problems include truck traffic and associated noise and litter. However, since operations take place within an enclosed structure at an incinerator, problems such as litter, odors, and insect and rodent infestation are better controlled than at a landfill. The by-products of incineration

— ash, gases, and heat — can be collected and reused to a large extent. And while incineration is a highly efficient method of waste disposal, there is some concern over the remaining by-products that cannot be reused.

Generally, the most controversial by-product is ash collected from scrubbers designed to take impurities out of the smokestack. According to *The Garbage Primer* from the League of Women Voters, an incinerator that burns 1,000 tons of trash per day can generate between 200 and 250 tons of ash a day as a residue. The composition and toxicity of this ash depends on the content of the waste burned and the efficiency of combustion. It must be specially treated as a hazardous waste and disposed in a special landfill.

Incinerators are expensive to build, operate, and maintain, making it most economical to build large plants so that cost-per-ton-of-waste accepted are lower. However, large sums of money must be borrowed to construct an incinerator, and whether the plant is running at half or full capacity, the agreed upon schedule of payments must be met. Therefore, although larger plants may be more economical, oversizing a plant can be very expensive and actually can create something of a “demand” for waste, something contrary to waste management goals. Facilities are perhaps best undersized but designed with space to add an additional incinerator unit should it be needed.

When They're Gone, They're Gone

6.III.1.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 - 8

Focus: Natural resources and wasteful use

Subject: Social Studies, Science

Materials: See list below

Teaching Time: Two class periods

Vocabulary: Natural resources, renewable and nonrenewable, sanitary landfill, recycle



Learning Objective

Students will:

- determine the difference between renewable and nonrenewable resources
- identify the problems of landfilling waste
- investigate options for saving nonrenewable resources
- explore the distribution of natural resources around the world.

Background

As countries become more industrialized and developed, they consume more natural resources. These natural resources may or may not come from the developed country. Most developed countries buy and import natural resources from other countries. For example, the United States is the world's top consumer of energy and a major consumer of natural resources. It ranks first or second in consumption of nine metals. One U.S. citizen consumes more than five times the world average of commercial energy supplies and even higher level of many other natural resources.

Natural resources are sources of material wealth within a country, such as timber, fresh water, or naturally occurring mineral deposits such as iron,

gold, bauxite, etc. A **renewable resource** is a natural resource that can be regenerated by natural ecological cycles or sound management practices. Timber and water generally fall into this category.

Nonrenewable resources are materials that are finite in number and cannot be regenerated. Petroleum and many mineral deposits are typical nonrenewable resources.

Learning Procedure

In this lesson, students will simulate the accumulation and consumption of the earth's natural resources. They will then discuss the problems arising from the unequal and wasteful use of natural resources.



According to the United States Energy Information Agency, petroleum accounts for about 40 percent, natural gas 23 percent and coal 22 percent of the resources used to produce energy in the United States.

Source: 1993 Environmental Almanac

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Materials

- 2# coffee can (or a bag)
- buttons, craft beads, small pieces of construction paper or candies in the following colors and quantities:

red	400
blue	104
green	12
orange	1
yellow	1
purple	1
clear	1

- 6 cups
- writing materials

Learning Procedure

1. Discuss the background material provided in this lesson.

2. As a class make a list of renewable and nonrenewable resources on the board. Explain that the beads (or similar material selected) represent nonrenewable resources. The number of beads reflect a mineral's relative estimated total of abundance, *not* the ease with which it can be obtained. Tell the students that these beads will be used in an activity later in the day.

3. Reproduce the chart, included, on the board.

4. Hide the beads throughout the classroom when the students are out of the room. Be sure to hide some in easy-to-find places and others in more difficult places.

5. Divide students into teams representing countries. To show increased potential in exploring for and money available to buy resources, vary the size of each group. (USA 6, Russia 6, Europe 4, Japan 3, Canada 2, Zambia 1)

6. Give the teams time to explore for resources (beads). Have them collect beads in the plastic cups: First, give the students two minutes to search around the room and then return to their group. Repeat the search a second time, but this time for only one minute.

After each exploration, students should separate and consider their results based on the beads they have gathered in their cups.

7. Discuss the greater difficulty in finding resources during the second exploration time. (*Competition becomes more intense for fewer resources.*) Discuss real-life examples of countries competing for resources. (*For example, wars in the Middle East over control of petroleum reserves.*)

8. Beads in the cups represent natural resources that are manufactured into products, used, and eventually discarded. Some natural resources are used for many years, while other natural resources are used for a very short time and end up in the waste stream.

9. Explain that much of what is thrown away is recyclable. Discuss the wastefulness of throwing natural resources into a landfill.

10. **Ask:** What can we do to extend the life of nonrenewable resources? (*Recycle.*) What are the advantages of extending the life of resources? (*More resources are available in the future, there may be fewer international conflicts, etc.*)

Questions for the Class

1. What will happen to the resources in the reserves if we continue this process? (*We will eventually run out; there may be conflicts with the more technologically advanced continents "winning;" more powerful continents may try to gain the resources of less powerful continents through trade, aggression, etc.*)

2. What can be done to stop wasting these resources? Make a list. Examples: recycle whenever possible, use less energy (*It takes less energy to recycle than to produce new products from raw materials.*), reduce unnecessary packaging.

3. How did you feel about the unequal accessibility of the resources? Discuss the "fairness" of the situation.

4. How did you feel about returning the resources to the can so they could be used again?

5. How much longer could we extend the process if we recycle? What will happen if the population increases? Will it become more necessary to recycle?

6. Should the development of renewable energy sources (solar, wind, geothermal) be increased because of the finite status of coal, natural gas and petroleum?

7. Ask these a few days after this exercise:

- Did you use a product made from a renewable resource today? If yes, what? What did you do with the product when you were through with it?

- Did you use a product made from a nonrenewable resource today? If yes, what? What did you do with the product when you were through with it?

- What can you do to conserve natural resources?

8. Discuss the future mining of sanitary landfills for natural resources.

Extension Activities

1. Research the nonrenewable resources represented by the beads in this lesson. What are the latest global reserve estimates and where are they found. *The U.S. Bureau of Mines produces a report entitled the Mineral Commodities. It can be obtained from the U.S. Department of the Interior in Avondale, Maryland.*

Develop and distribute "How to Recycle" information to the school administration, neighbors, local businesses, community centers, or the media.

2. Hold an all-school assembly complete with skits and talks given by the students about the importance of resource conservation.

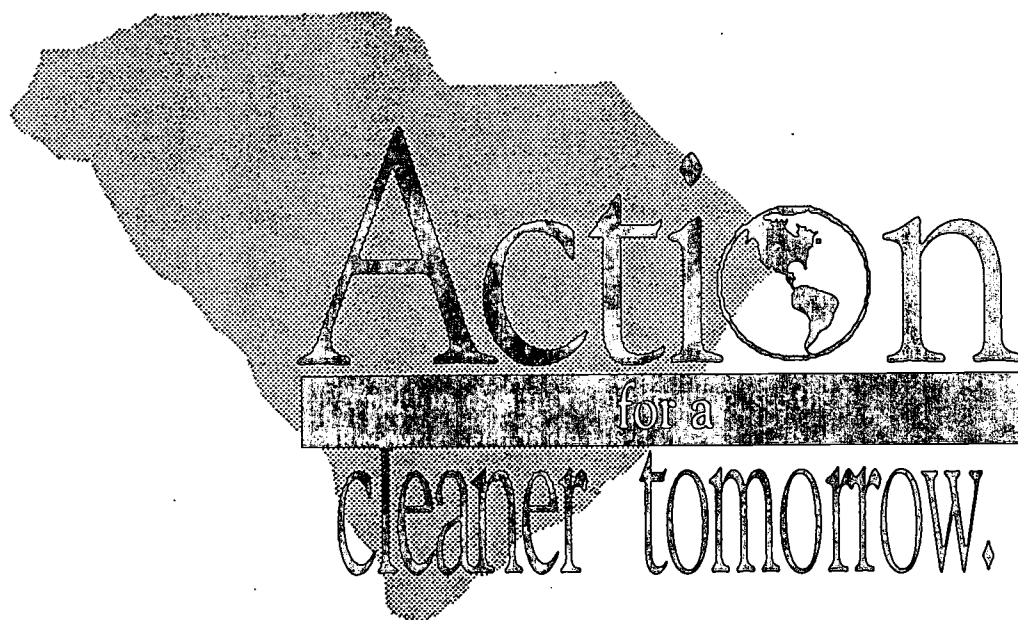
3. Have students pick a country and research its natural resources. Write a paragraph describing imports, exports, and consumption.

Just Do It

Conserve resources at home. Mine valuable paper, glass, plastic, and aluminum in the trash and recycle it; conserve energy by turning off lights and turning down the heat and turning up the air conditioner; reduce your family's use of convenient "throw-away" products that turn resources into waste.

Distribution of Beads as the Earth's Resources

Color	Number of Beads	Finite Resource Represented
Red	400	Iron in Ore
Blue	104	Bauxite (aluminum ore)
Pink	31	Chromium
Green	12	Copper
Orange	1	Lead
Yellow	1	Tin
Purple	1	Silver
Clear	1	Platinum



A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Fast Food Survey

6.III.2.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6-8

Focus: Excessive packaging in fast foods and convenience foods

Subject: Science, Social Studies, Math, English

Materials: See *Fast Food Survey* with this lesson

Teaching Time: Two class periods (Best to begin this on Friday) requires after school work

Vocabulary: Recyclable



Learning Objective

Students will:

- evaluate the trash generated by fast food restaurants and packaged convenience foods
- become aware of the frequently excessive packaging used in the fast food and convenience foods industries
- differentiate recyclable waste from non-recyclable waste.

Background

Kids love to spend their free time eating convenience foods and socializing at various fast food establishments. Some restaurants are known for the volume of non-recycled trash they generate. Others have made an all-out effort to help solve the problem.

It is essential to solving the solid waste dilemma in this country to reduce the amount of trash produced.

Many foods use packaging that is not, at present, readily **recyclable**.

Learning Procedure

Day 1

1. **Ask:** How many times per week do you eat at a fast food restaurant? (Determine the average number of visits per week for the class.) **Ask:** How much trash do you throw away from each visit? (With the class estimate the number of bags of trash per year.) **Ask:** Is all of this trash necessary?
2. Discuss the types of packaging used by various convenience foods and fast food restaurants. List these on the board. (*burger boxes; french fry sacks, bags, boxes and cups; single-serving plastic microwave containers, pizza boxes; etc.*) Discuss the purposes of the packaging (*stacking, warmth, sanitation, appearance, aesthetics, individual servings, advertising*).
3. Have the students define the word "recyclable."
4. Divide the students into groups of four. Have the groups divide the list of packaging types on the board into two categories: recyclable and non-recyclable. Then have the groups discuss the following
 - Do fast food restaurants recycle their trash? (If they don't have special receptacle for recyclables in the restaurant, they probably aren't recycling.)

DOWN TO EARTH



According to the book, *50 Simple Things You Can Do To Save The Earth*, "it takes 1,630,000 gallons 6,170 kl of water to feed an American for a year."

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Restaurant employees do not sort the trash for recyclables.)

- Why wouldn't a restaurant recycle? (*Time, money, health and cleanliness concerns, etc.*)
- Why would they? (*Good for public image, corporate conscience, etc.*)
- Do convenience foods generate excessive waste?

5. Instruct the students to visit (or recall a visit to) a fast food restaurant and complete the *Fast Food Survey*. Tell the students that their job is to observe the amount of trash and kinds of trash generated by a fast food restaurant. Each group member is to visit a different restaurant (or they can go in small groups). This will allow for a better overall survey. This activity can also be done with each group member recalling the packaging and trash generated from different fast food chains.

Day 2

1. After the students complete the survey, reconvene the group and have them discuss their surveys with other class members. Encourage them to give as much detail as possible about their visit. Compare trash/packaging on take-out orders to eat-in orders.

2. Using the formula on the work sheet, the groups are to determine the percentage of recyclable trash disposed of by the various restaurants. They then decide which restaurant, if any, seems most concerned with trash disposal and the environment and why.

3. Have the group consider what to do about trash disposal in food restaurants and suggest ways to remedy the problem. Are following ideas are feasible:

- Recycling bins for paper, plastic and aluminum
- Trash compacting
- Reduction in packages and wrappers.

Extension Activities

1. To demonstrate the volume of trash generated by fast food restaurants, have the students collect all the fast food trash they can for a day or a week

Then have them sort the trash into recyclable and non-recyclable stacks. (Only clean trash, no food.)

3. Have a fast food restaurant manager come to your class to discuss what his or her restaurant is doing about waste generation and the environment.

4. Have the students write a letter to the president of their favorite fast food restaurant expressing their concerns about this problem. In the letter, they should state that they have observed the problem firsthand. Offer possible solutions.

5. Encourage students to:

- Ask for their food wrapped in paper only - not have their food bagged if it is only a few items
- Keep track of the volume and types of solid waste trash generated in preparing meals at home. What could they do to reduce the amount of waste generated through meal preparation at home? (*Recycling, picky purchasing, recycling at home*)
- Develop an article for your school newspaper reporting on the project.

6. Ask the students to consider what the phrase *Think Globally, Act Locally* means. Have them write a paragraph.

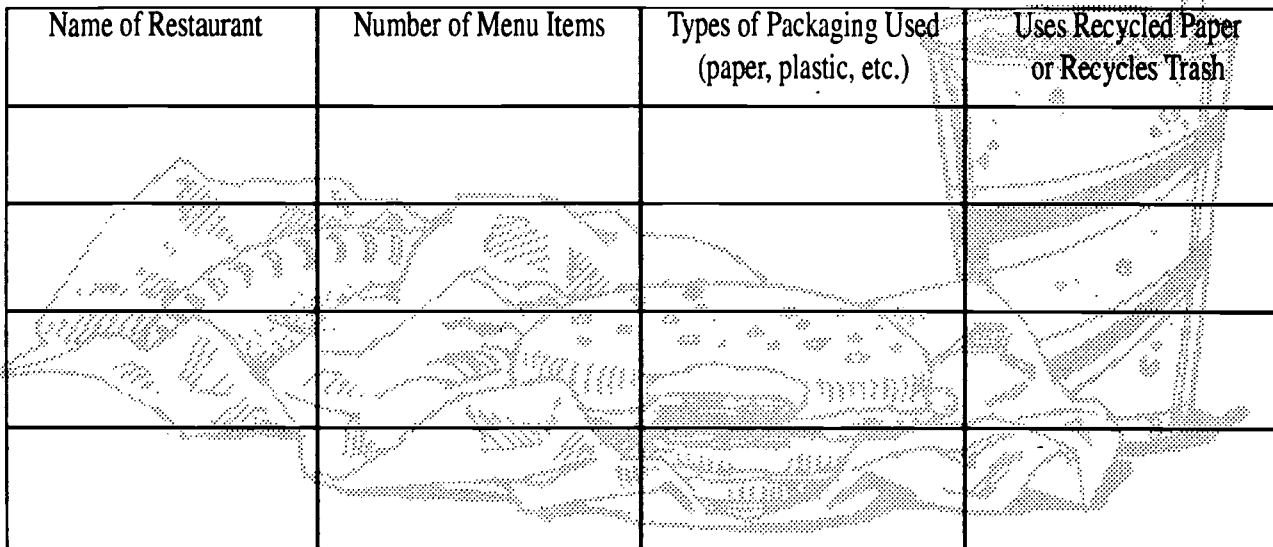
7. Write a proposal to the cafeteria manager or principal suggesting improvements that can be made regarding waste in the cafeteria.

Just Do It

For more information about minimizing fast food trash, contact:
The Society of the Plastics Industry
1-800-243-5790

DO FAST FOODS EQUAL LONG-LASTING TRASH?

WORKSHEET



Name of Restaurant	Number of Menu Items	Types of Packaging Used (paper, plastic, etc.)	Uses Recycled Paper or Recycles Trash

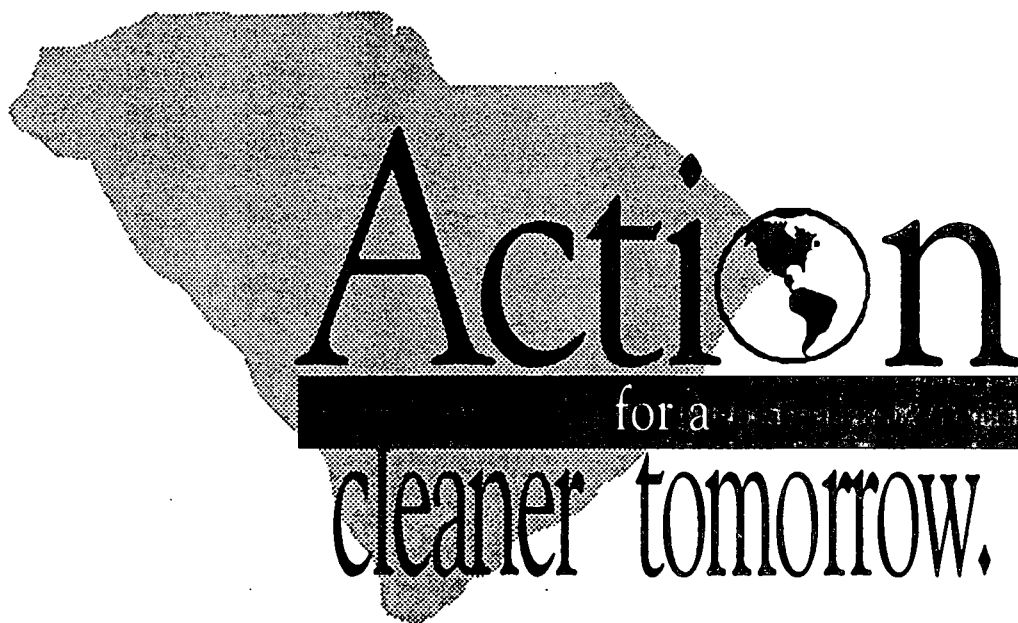
In this activity you are asked to observe the types and amounts of packaging/trash generated by fast food restaurants. Keep alert for the recycled paper symbol. This is a big plus for the restaurant. Take good notes on what you observed because you will report your findings to your group.

Do any restaurants offer any types of recycling options? What are those options?

To determine the percentage of packaging items that are recyclable, use the following formula:

$$\frac{\text{recyclable packaging}}{\text{\# of items on menu}} \times 100$$

Hint: Recyclable packaging includes all paper, plastic, straws and cups, clear wrap, aluminum, and glass products.



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1-800-768-7348.

Oil & Water

6.III.3.F

Preparation Time:

Easy To Do

Moderate

Extensive

Grade: 6 – 8

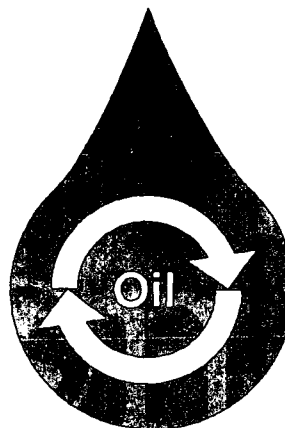
Focus: How oil pollutes water

Subject: Science, Social Studies

Materials: See list of materials itemized below

Teaching Time: Two class periods

Vocabulary: Dilute, photosynthesis, carcinogens, plankton



Learning Objective

Students will:

- see how oil pollutes water
- test water samples for the presence of oil
- perform an experiment to determine one part per million.

Materials

If possible, assemble several sets of these materials so that the class can perform the experiment in small groups, otherwise use one set of materials and perform the experiment as a class. One set of materials includes: seven test tubes (OPTION: seven same-sized jars, such as baby food jars), test tube rack, 10 ml graduated cylinder, olive oil, 250 ml beaker, brown paper bag (cut in strips), blue food coloring, wax pencil, eye dropper (or calibrated straw).

Background

Have you ever heard the saying, “Oil and water don’t mix?” Oil in any form can have an affect on our environment. Some studies have shown that after a shoreline spill, it may take up to 20 years for the environment to return to its original

condition. (For more information, see the Resource section on Used Oil.)

When oil ends up in water, a film of oil on the surface can block **photosynthesis** and slow the production of oxygen. The reduced oxygen supply then causes stress to the point of death in aquatic organisms. Large organisms such as mammals and birds are the most familiar victims of oil pollution because of their visibility and emotional appeal to people. Feathers and fur stick together, become matted and lose their ability to insulate animals against cold. Death may result from temperature shock or from ingesting (or eating) oil as the animals try to clean it from their coats.

Oil in water can also affect other organisms. Some of the components of oil may evaporate into the air or dissolve into the water. Many of the compounds are **carcinogens**. Some of the oil spilled into an aquatic environment settles to the bottom, affecting the organisms living there. Oil can clog breathing structures or be absorbed into tissue and then passed along the food chain, even to humans who eat fish or shellfish. Oil may

DOWN TO EARTH



There are more than 550 million motor vehicles operating worldwide, each of these vehicles averages three oil changes each year. The United States leads the world in the number of cars per capita. Africa and Asia, with three-fourths of the world's population, have only 12 percent of the world's cars.

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harm bacteria or **plankton**, the basis of the food chain.

One gallon (3.8 liters) of used oil can potentially destroy 1 million gallons (3,785,000 liters) of fresh water – enough to supply 50 people with drinking water for an entire year. One pint (1/2 liter) of oil can produce a slick on water about one acre in size and will kill floating aquatic organisms.

The U.S. Coast Guard estimates that sewage treatment plants discharge twice as much oil into coastal waters as do tanker accidents. A major source of this pollution is from oil dumped by individuals into storm drains and sewers. Unfortunately, even a little used oil can go a long way in polluting soil, streams and lakes.

What Can We Do With Used Oil?

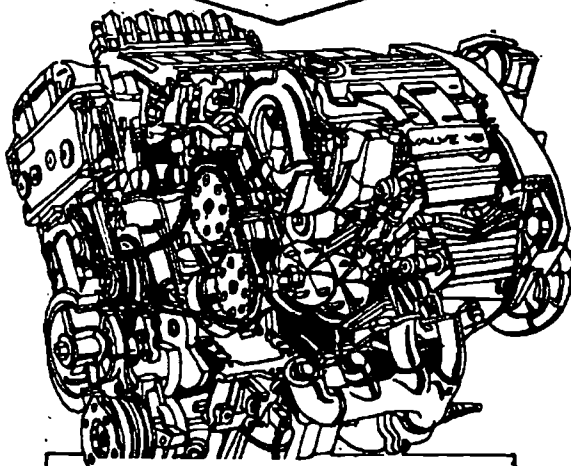
Recycling used motor oil makes good sense. It not only eliminates a health hazard and protects the environment, it also saves energy. All automotive oils can be recycled safely and productively and can be used again as a fuel, lubricant or other petroleum products.

While it takes 42 gallons (159 liters) of crude oil to produce 2 1/2 quarts (2.4 liters) of lubricating oil, only one gallon (3.8 liters) of used oil can be turned into the same 2 1/2 quarts (2.4 liters) of lubricating oil. And it's good quality oil, too. According to studies by the National Bureau of Standards, the Army, and the Department of Energy, re-refined oils perform as well as virgin oils. However, you should consult owners manual before using re-refined motor oil.

It's not just the oil that poses a threat to the environment. Many additives and contaminants help make used oil toxic. As much as 20 percent of automotive oil is composed of substances that are added to improve performance, inhibit rust or prevent foaming. Oil will also pick up sediment and gasoline components and additives from the engine during combustion. High levels of lead, as well as other toxics including benzene, cadmium, zinc, magnesium, and PCB's may be

Your car's motor oil ... coming and going

New motor oil contains:
pour point depressant;
detergent; foam, oxidation, rust
and corrosion inhibitors;
viscosity index improvers;
anti-wear additives



Used motor oil contains:
• all the original ingredients
PLUS
water and dirt, iron and
steel, copper, heavy metals
including lead, cadmium,
zinc, barium, sulfur, ash

present in oil and may contaminate the environment if not properly handled.

Used oil should never be emptied into sewers or storm drains, or dumped directly onto the ground to kill weeds or to suppress dust on dirt roads. Also used oil should never be thrown into the trash where it will end up in landfills.

Learning Procedure

Day One

1. Review the background materials on the environmental affects of oil with the class.
2. Have students perform the following experiment to demonstrate how small quantities

of oil can pollute large amounts of water.

Perform the experiment as follows:

- a) Measure 100 ml of blue water into your 250 ml beaker.
- b) Add 9 ml of blue water to each test tube in your test tube rack.
- c) Calibrate the eyedropper to measure 1 ml. This can be done by adding 10 ml of this solution to your cylinder and then drawing out water, using the eyedropper, until the level in the cylinder reaches the 9 ml mark. Use the wax pencil to mark the water level in the dropper.
- d) Pour out unused water from your cylinder and measure out 1 ml of olive oil. Add this to test tube #1.
- e) Shake the test tube thoroughly. Quickly, before the oil and water separate, remove 1 ml of this solution with your calibrated dropper and add it to the next test tube (#2).
- f) Repeat step e) until you feel that there is no oil left, checking either visually or by smell. Repeat step e) no further than test tube #7; at this point, you will have a dilution of one-one millionth.
- g) Check for oil in your solution by dipping a strip of brown paper 5" (12.7 cm) long by 1/2" (1.3 cm) wide into the test tube. If you don't observe the oil immediately, label your strip and set it aside to dry overnight.
- h) Clean up your lab area and materials. Use warm water and soap to remove all traces of oil in all the test tubes.

Day Two

3. Check the brown paper strips for oil spots.
4. Have students answer the Questions for the Class individually or as a group.

Questions for the Class

1. Did you find oil spots on the brown paper the next day? (yes)
2. Where do you think this oil would go in nature?

(It might end up in our lakes and rivers or in our ground water sources. It might be ingested by fish and animals and by people.)

3. What are some of the contaminants found in used oil? *(Used oil contaminants include heavy metals such as lead, cadmium, zinc, barium, chemical additives, dirt, iron, and steel particles.)*
4. Did the water **dilute** the oil completely? *(no)*
5. List items you or your family own that use oil and have the capability of contaminating the environment. *(This list might include lawn mowers, cars, boats, gas powered tools such as chain saws, string trimmers and leaf blowers.)*
6. What can you do with used oil to prevent it from becoming a source of pollution? *(Take it to an oil recycling station such as the ones in the South Carolina Used Oil Partnership's program.)*

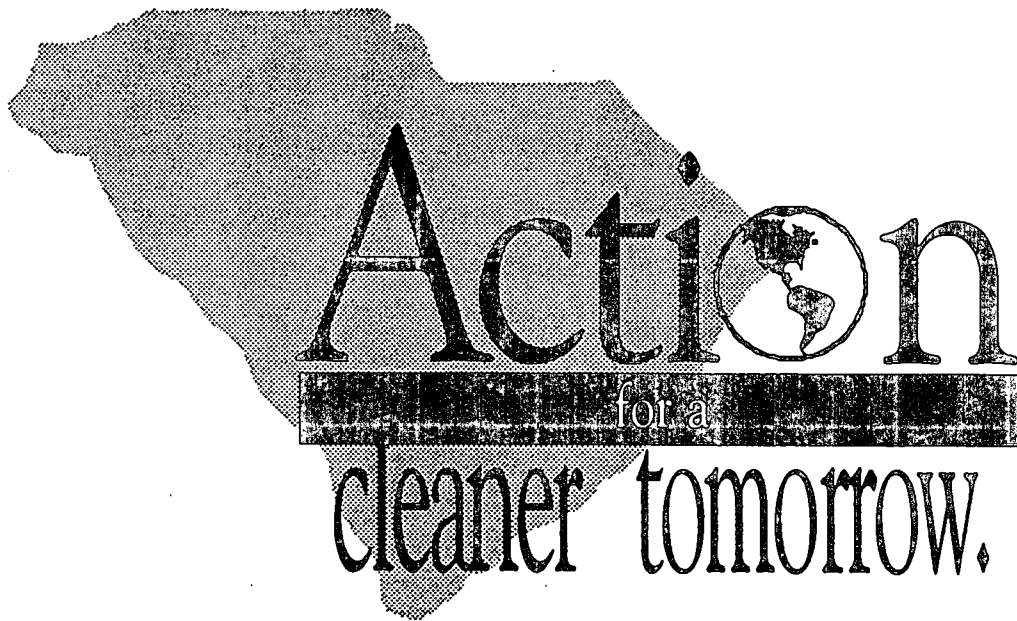
Extended Learning

1. Have students prepare posters promoting oil recycling and how to collect used oil for recycling. Ask local service stations and automotive stores to display them.
2. Have students investigate what your school district does with the used oil from school buses and other maintenance equipment. Have students calculate how much used oil your school district must handle during the school year. *(How many vehicles times how much oil per oil change times how many oil changes per year.)*
3. Have students research and prepare reports on how oil is recycled into energy in South Carolina.

Just Do It

Recycle used oil at one of the more than 250 used oil recycling centers across the state.

For more information on used oil recycling in South Carolina call, 1 800 76 USE IT.



A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Where Did The Waste Problem Come From?

6.IV.1.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

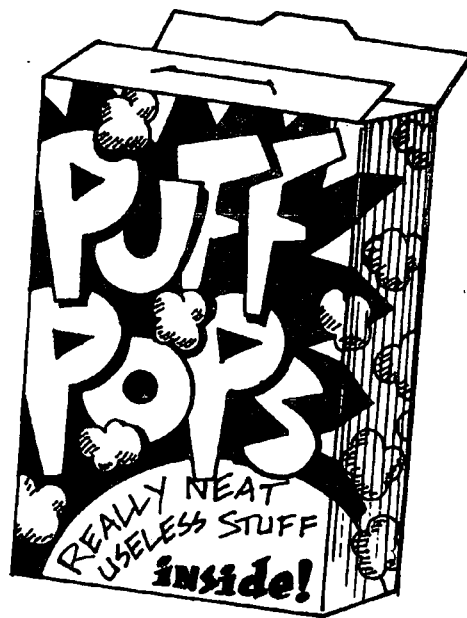
Focus: Consumerism, packaging waste

Subject: Social Studies

Materials: See list below

Teaching Time: One hour

Vocabulary: Recycling, packaging, advertising, renewable, nonrenewable, biodegradable, non-biodegradable



Learning Objective

Students will:

- learn how our consumer-oriented lifestyles contribute to the problems of solid waste.

Background

Solid waste has increased more 50 percent, from 2.65 pounds (1.2 kg) per person per day in 1960 to about 5.6 pounds (2.52 kg) per person per day today in 1996. This increase can be attributed to a growing reliance on convenience items: convenient for use and for disposal. Along with this trend, of course, the population has increased as well. Between 1970 and 1986, the U.S. population increased by 18 percent but its trash output increased by 25 percent.

It is estimated that 33 to 40 percent of the solid waste generated in the United States is **packaging**, more than 44 million tons each year. Packaging is designed to protect its contents from physical damage and spoilage, and therefore, allows transportation of goods from far away, without adding broken or rotten products to the waste stream.

In the United States, it is estimated that only 12 percent of transported food spoils, while in the former Soviet Union, it is estimated that some 50 percent of transported food spoils.

Packaging not directly related to protecting products from breakage or spoilage is considered excessive by environmentalists. Much of this packaging is **advertising**, designed to help sell the product.

Packaging is made from a variety of materials, some recyclable or compostable, and some not. More and more, metal, glass and paper/cardboard materials ... **all recyclable or compostable** ... are being replaced by plastic or multi-type, multi-layered materials which are almost impossible or very expensive to recycle or compost.

Just how much does packaging cost? One dollar out of every \$11 spent on food and beverages goes for packaging.



Packaging labels are just beginning to be regulated in the United States. According to experts, the words "environmentally safe" or "environmentally friendly" are legally meaningless.

Materials

Collect a variety of consumer products that students can examine and discuss in class. (Option: Have students bring in samples of these products.) Try to find products that fit into several categories such as:

- single use items
- reusable items
- items that come in packages that may be reused
- high-convenience products (You may want to list alternatives.)

Product examples include:

- a package of chewing gum
- a complete pizza mix with crust, sauce, and cheese
- a complete cake mix
- a two-liter, plastic drink bottle
- a wrapped men's shirt
- a plastic ice cream tub
- a watercolor paint set
- an empty pickle jar
- disposable tableware
- a TV dinner
- a "snack" lunch product

Learning Procedure

1. Review the Background information and the related information in the Resource Section with the class.
2. Divide the class into groups and distribute the sample products.
3. Ask the students to open the products and examine the contents and packaging. What is the packaging made of? What is the packaging's function? Is it adequate/excessive? What is the best method of disposing of the packaging?
4. Ask the groups to report to the class about their particular product(s).

Questions for the Class

1. How many of these packages are a) reusable, b) recyclable/compostable or **biodegradable** (can recycling or composting be done locally?), c) excessive, d) made from a **renewable** or **nonrenewable resource**, or e) adequate and necessary for the protection and preservation of the product. NOTE: This list could be made into a chart for the group or classroom discussion.
2. How much trash would we have to throw away after we took out the recyclable or reusable materials?
3. Are there alternatives to packaging?
4. What effect would buying larger packages (*buying in bulk*) have on the amount of waste coming out of your home? What effect would it have on your individual lifestyle at home? (*storage space, ease/difficulty of use, higher up-front costs vs fewer trips to the grocery store, etc.*)
5. What effect does bulk packaging of products have on the retailer? (*You might want to discuss the physical differences between a grocery store and a warehouse-style, wholesale shoppers club.*)

Just Do It

Bigger is better when it comes to packaging of ordinary consumer goods. When you buy in bulk, you get more product and less packaging to throw away. Is your favorite product – like your breakfast cereal – available in recycled or recyclable packaging? If not, write the maker a letter and let them know you'd prefer it. Also, let your grocer know you are interested in bulk-sized packages. Or maybe you could change your lifestyle and get a new breakfast cereal.

Environmental Shopping

6.IV.2.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: How to buy less waste, resource conservation, consumer awareness

Subject: Home Economics, Social Studies, Math

Materials: Student handouts included

Teaching Time: 45 minutes in addition to student time to conduct survey

Vocabulary: Renewable resources, nonrenewable resources, organic

Learning Objective

Students will:

- see how careful buying is the first step in solving our solid waste problem
- understand how recycled materials are used in packaging
- determine which natural resources are used in packaging and how these resources can be conserved through careful buying and recycling.

Background

According to "Realizing Recycling's Potential" by Cynthia Pollack-Shea, nearly \$1 out of every \$11 spent for food and beverages in the United States pays for packaging. The food packaging bill in a single year totals as much as \$28 billion; this is more money for packaging than the farmers receive in income.

Many other consumer goods also suffer from over packaging.

Learning Procedure

1. **Ask:** How can you reduce the amount of packaging you throw away? Encourage students to brainstorm their ideas.

2. Explain to students that they will be analyzing products and packaging in surveys that they will complete for homework. You may want to divide the class into small groups for this assignment.

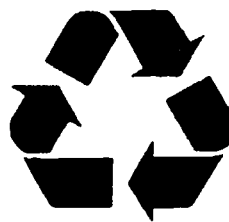
3. To complete these assignments, students must understand these terms:

- **Organic** - derived from living organisms

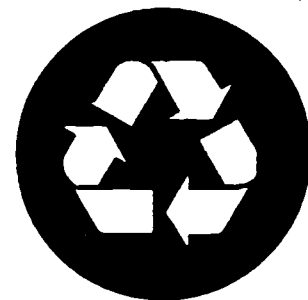
- **Renewable Resources** - naturally occurring raw materials derived from an endless or cyclical source such as the sun, wind, falling water, fish and trees. With careful management, the consumption of these resources can approximate the replacement by natural or human-assisted systems.

- **Nonrenewable Resources** - naturally occurring raw materials which, because of their scarcity, the great length of time required for their formation, or their rapid depletion, are considered exhaustible. For example, petroleum.

4. Review how to identify packaging made from recycled materials (*Look for the recycling symbol.*)



Recyclable



Recycled

DOWN TO EARTH



99.5 percent of all the fresh water on Earth is in ice caps and glaciers.

Source: National Geographic

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5. Distribute copies of Survey 1: *Product & Packaging*. Have students choose 10 products and complete the survey chart for each. Have students choose products that come in a choice of packaging and forms, such as cookies, rice, pasta or beverages.

Follow-up Questions for

Survey 1: *Products & Packaging*

Have students answer the following questions:

- Which products need special packaging to protect public health?
- Which packaging was made from recycled materials?
- Which products could be bought in bulk or large containers?
- Which products could be bought in a less processed or packaged form?
- Which packaging could be improved to save energy and resources and reduce waste?

6. Distribute copies of Survey 2: *A Potato By Any Other Name*. For homework, have students find a variety of potato products and complete the survey information. A guide is included with this lesson that shows some of the forms of potatoes students are likely to find.

Follow-up Questions for

Survey 2: *A Potato By Any Other Name*

- What effect do processing and packaging have on a product's cost?
- What effect does package size have on cost?
- What effect does package size have on the amount of waste?
- What else is added to food as it becomes more highly processed?
- List examples of recyclable packaging.
- List examples of products for which recyclable packaging is not available.
- List examples of packaging made from recycled materials.
- List ways people can reduce waste and increase recycling through careful buying.

Extension Activities

1. Have students create a guide to packaging that is recyclable in your area. Have them bring in samples of these recyclable packaging choices and packaging that is reusable. With these samples, have students create a display in the class or for the school. Be sure to include the specific types of plastic, by code number, that are accepted for recycling in your area. (*See the lesson entitled Plastics By The Numbers.*) For example, if milk jugs can be recycled in your area, then milk in plastic jugs is a better choice than milk sold in cardboard cartons that would end up in the trash and in the landfill. If a consumer has a choice between a product packaged in #7 Plastic or glass, recyclable and/or reusable glass is the better option.

2. Have students publish their packaging guide in the school newspaper. Have students illustrate packaging that can be recycled locally and where to take these items if curbside recycling is not available.

3. Two organizations, Green Cross and Green Seal, research and certify products based on different levels of environmental impact. Green Seal has a brochure on labeling. Send a self-addressed, stamped envelope for a class copy to Green Seal, 1875 Connecticut Ave., NW, Suite 300A, Washington, D.C. 20009. The Green Cross Certification Company, Consumer Affairs Department can be reached by writing 1611 Telegraph Ave., Suite 1111, Oakland, California 94612, or call (800) 829-1416.

Just Do It

Make a list of items available in recyclable containers that your family buys often. Make sure everyone in the family understands these containers should be recycled when empty. Also review your buying habits and eliminate as many non-recyclable or non-reusable containers from your shopping list as possible.

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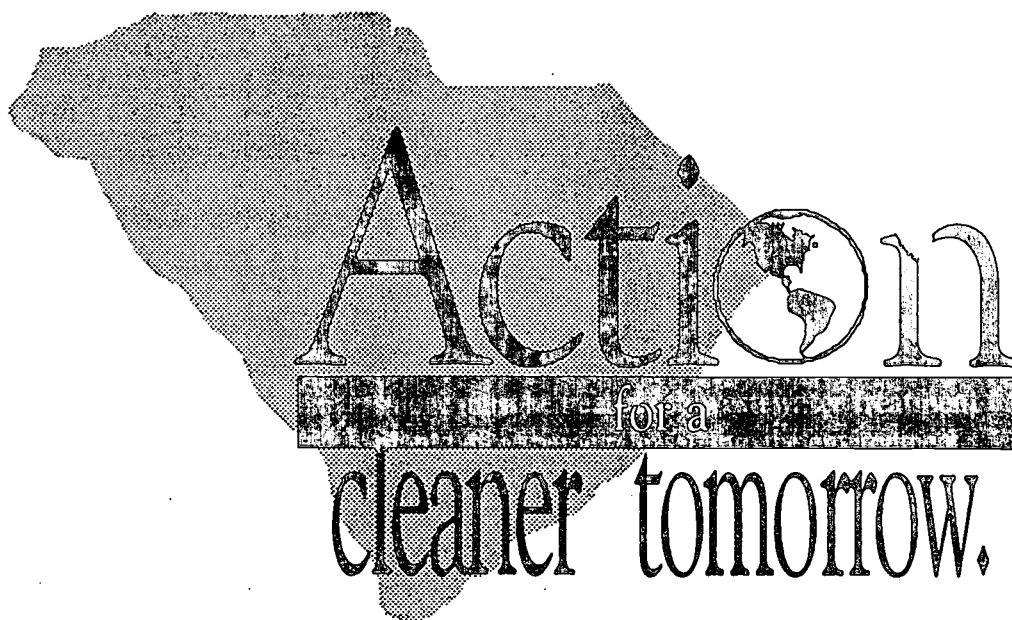
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A Potato By Any Other Name

(*Replace with local brands if necessary.)

Product*	Package Size	Price	Price Per Pound	Recyclable Package?
Russet potatoes	bulk		\$0.59	
White Potatoes	bulk		\$0.49	
Red Potatoes	bulk		\$0.69	
Fresh Potatoes	5 lb. (2,268 g)	\$1.67	\$0.338	
Fresh Potatoes	10 lb. (4,536 g)	\$2.49	\$0.249	
Bel-Air hash browns	2 lb. (907 g)	\$1.29	\$0.645	
Bel-Air french fries	2 lb. (907 g)	\$1.59	\$0.795	
Bel-Air shoe string potatoes	20 oz. (567 g)	\$1.39	\$1.12	
Ore-Ida potatoes O'Brien	24 oz. (680 g)	\$1.49	\$0.994	
Ore-Ida golden fries	32 oz. (907 g)	\$1.69	\$0.85	
Ore-Ida dinner fries	24 oz. (680 g)	\$1.79	\$1.20	
Betty Crocker potato buds (box)	28 oz. (794 g)	\$2.99	\$1.70	
Betty Crocker potato buds (box)	13.75 oz. (390 g)	\$1.49	\$1.73	
Town House mashed potatoes (box)	16 oz. (454 g)	\$1.39	\$1.39	
Town House white potatoes (canned)	15 oz. (425 g)	\$0.57	\$0.608	
S & W whole potatoes (canned)	16 oz. (454 g)	\$0.75	\$0.75	
O'Boises potato chips	6.5 oz. (184 g)	\$1.15	\$2.83	
Eagle potato chips	6.5 oz. (184 g)	\$1.09	\$2.68	
Pringles	7 oz. (198 g)	\$1.50	\$3.42	
Lays potato chips	10.5 oz. (298 g)	\$2.28	\$3.47	
Ruffles potato chips	15 oz. (425 g)	\$2.75	\$2.93	
McDonald's french fries	3.5 oz. (99 g)	\$0.67	\$3.06	



A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Glass Making

6.IV.4.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6–8

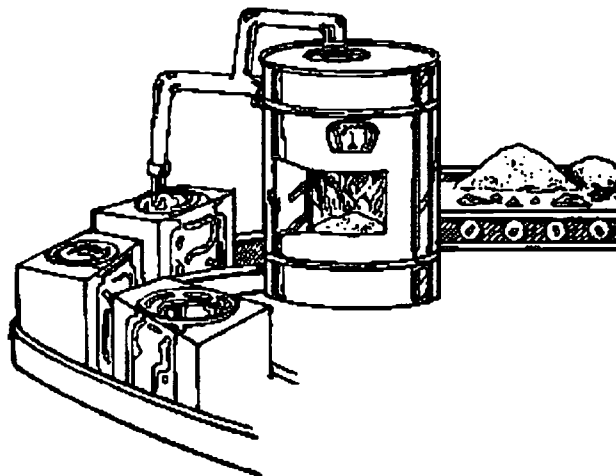
Focus: Glass manufacturing and recycling

Subject: Science, Art, Social Studies

Materials: See list below

Teaching Time: Two 45-minute periods

Vocabulary: Heat, energy, natural resources, reuse, recycle, cullet, minerals



Learning Objective

Students will:

- recall some of the processes and resources in the manufacture of glass products
- describe how recycling glass is good for the environment
- make “glass” from spun sugar
- simulate glass blowing.

Background

Glass accounts for 6.6 percent of the solid waste stream generated in South Carolina. Glass is 100 percent recyclable, meaning that every pound of glass bottles and jars brought to a recycling center can be used to make new glass containers. (Mirrors and tempered or tinted glass for windows cannot be recycled.)

Glass is made by heating sand, lime, soda ash and **cullet** (crushed glass that has been collected for recycling) to a very high temperature until the mixture melts. As it cools, it is poured into molds and injected with air.

All bottles and jars were once made by glass blowers who blew bubbles with the molten glass mixture and formed them into shapes which

hardened as they cooled. Today’s manufactured bottles and jars are formed by injecting air into the molten glass mixture within molds.

The following activity simulates the making of glass, substituting sugar for sand, lime, and ash. This activity also simulates a common processes of plastics-making, called “blowmolding.” Your students may also be interested to know that “sugar glass” is used in movie-making for “breakaway” windows and bottles. (For more information on glass, see the Resource section.)

Materials

- *Glass Manufacturing* illustration
- variety of glass objects (different shapes, colors and functions)
- for making glass (per group): 1 cup (50 g) sugar, hot plate, pan, 8” (20 cm) square sheet of glass (or substitute an 8” x 10” (20 cm x 25 cm) piece of glass from a picture frame), 1/4-cup (12 ml) water, newspaper, safety glasses, tongs or hot pad,



More than 95 percent of the United States residential curbside collection programs include glass.

Source: Glass Packaging Institute

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balance, graduated cylinder, 250 ml beaker
• For molding glass (per group): 1 wide-mouth glass jar); per student: 1 stiff straw or glass tubing, balloon, rubber band

Learning Procedure

1. Hold up a glass object. **Ask:** Is this glass a solid or a liquid? Tell them glass is a liquid that has been cooled to form what appears to be a solid. Although it seems solid, glass remains a liquid. It's easy to see the effects of this in windows in old homes, for example. Glass, and the light coming through older windows, become distorted over time because the glass tends to "flow" toward the bottom.

Have the students touch the glass and describe the colors, shapes, and textures. Ask them what uses the many kinds of glass objects have. Hold the objects to the light and show how some reflect light, some are clear, and others are opaque.

2. Display the *Glass Manufacturing* illustration and explain to students how glass is made, emphasizing the **heat** and **energy** required during the process. Explain to students that the **minerals** are taken from the ground and heated to very high temperatures to make them melt. This process requires enormous amounts of energy. The supply of minerals and energy used to make glass is limited so we should not throw glass away.

3. Explain to students that glass jars can be re-melted to make new glass so these natural resources can be recycled. Ask students why recycling glass is good for the environment. (*Recycling glass reuses the natural resources which are in limited supply, saves energy.*)

4. Tell students that South Carolinians throw away most of the glass used in packaging. Ask students where the glass goes when it is thrown away. Explain that there is no such place as "away" and that all trash has to go someplace. Tell students that place is called a landfill. Explain that space in landfills is growing scarce because of how much we throw away and that we should try not to throw away so much trash. Ask if anyone knows how they

can teach people not to throw away their glass. Write students' suggestions on the board.

5. *Remind students to practice good safety habits during this step of the procedure.*

Start heating the water. Tell students you are going to make "pretend" glass using sugar in place of the real materials. Let students examine the sugar and describe it in terms of color, texture, shape and taste. Point out that the minerals used to make real glass are similar, but they come from the ground. Ask a student to describe sand. Have them describe the water and the changes in it as the heat begins to make it boil. Point out that heat energy is being used and show students the steam produced when water is boiled. Pour the sugar into the boiling water. Tell students to pretend the sugar is the minerals from the ground. Stir the mixture vigorously over the heat until the sugar is dissolved (about 5 minutes). Ask students to describe the changes in the sugar and water. Tell them this is how glass looks before it cools. Put several layers of newspaper under the sheet of glass. Carefully pour the mixture onto the sheet of glass and allow to cool (about 15 minutes). Proceed to the molding glass experiment.

6. Hold up the two sheets of "glass" so students can see through them. By allowing it to set overnight, the "glass" will become frosted. The next day, ask the students to describe the changes that occurred overnight.

7. (Optional) To illustrate the recycling of glass, scrape the dried "glass" back into the pan (call it "cullet," small pieces of crushed, recycled glass); add water and re-boil. More sugar will have to be added to repeat the procedure. Ask the students which resources were replaced when the cullet was used to make the new glass (*minerals, energy*).

Molding Glass

1. Divide the class into small groups of 4 - 6 students. Give each group a wide-mouth jar.

2. Give each student a straw or glass tubing, balloon and rubber band.

3. Attach the balloon to the straw with the rubber band.

4. Have students take turns putting the balloon into the jar and blowing it up until it takes the shape of the jar.

5. Explain that this process illustrates how glass is molded into a jar or other shape.

Extension Activities

1. Ask students to name some of the processes and natural resources used to manufacture glass. Students may illustrate the process, labeling the “natural resources” used to make glass and showing which ones are replaced when recycled glass (cullet) is used as a raw material.

2. Bring samples of handmade glass to class and show students the bubbles in the glass formed by a person blowing air into the hot glass mixture. Point out the irregularities that show the glass was handmade.

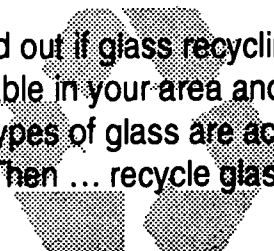
3. Have students research innovative uses for recycled glass such as “glasphalt” and insulation.

4. Have students write to the Carolinas Glass Recycling Program, 908 South Tryon Street, Suite 2200, Charlotte, North Carolina 28202, for information on glass recycling in the Carolinas.

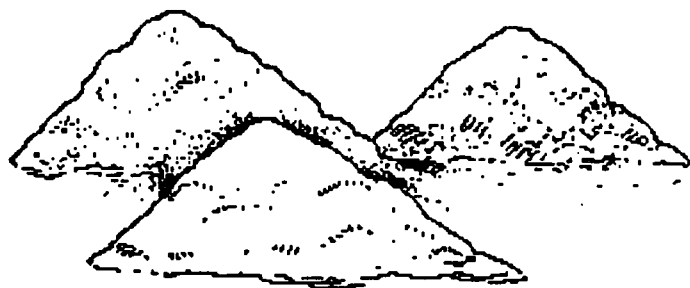
5. Invite a glass blower to class to explain the techniques and demonstrate the art.

Just Do It

Find out if glass recycling is available in your area and, if so, what types of glass are accepted. Then ... recycle glass!



Glass Manufacturing

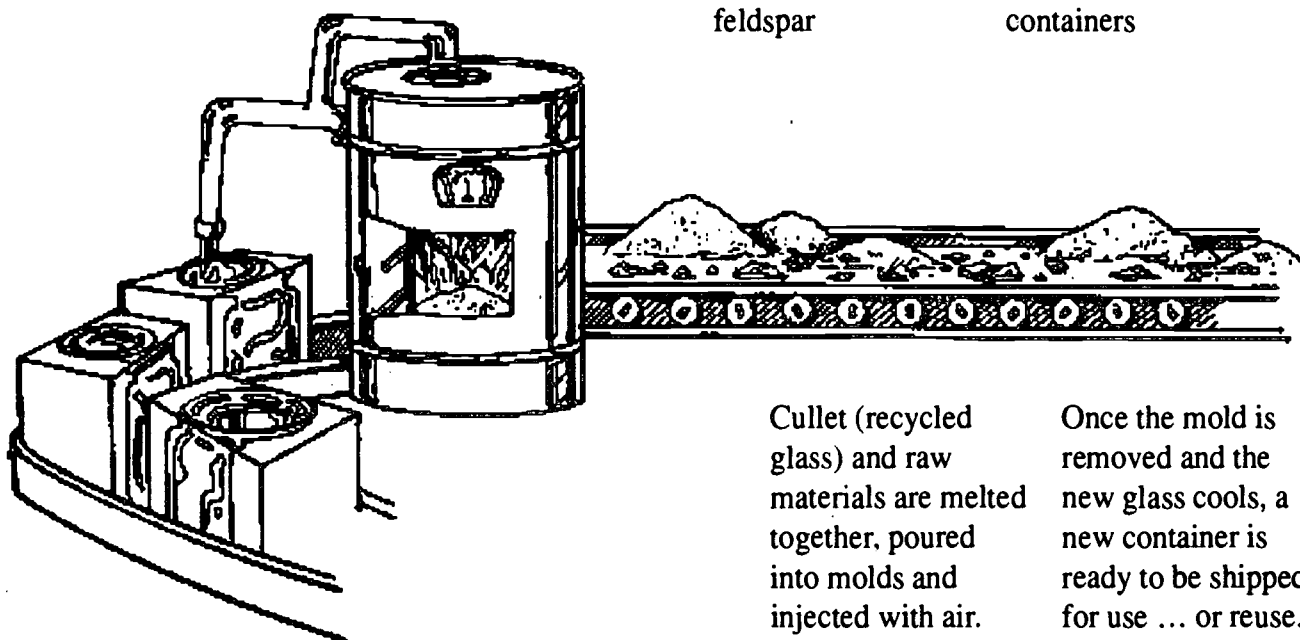


Raw Materials:

sand, soda ash,
limestone,
feldspar

Recycled Materials:

cullet or glass to be
recycled into new
containers



Cullet (recycled glass) and raw materials are melted together, poured into molds and injected with air.

Once the mold is removed and the new glass cools, a new container is ready to be shipped for use ... or reuse.

1,330 pounds (603 kg) of sand, 433 pounds (196 kg) of soda ash, 433 pounds (196 kg) of limestone,

151 pounds (68 kg) of feldspar and 15.2 million Btus of energy are required to make just one ton of glass.

Major deposits of white sand suitable for making glass are found in Illinois, New Jersey, the Alleghenies and the Mississippi Valley. Most soda ash comes from Wyoming and 65 percent of the feldspar in the United States comes from California and North Carolina.

Different colored glass is produced by adding small amounts of other substances such as iron, copper and cobalt. Green glass is made by adding iron.

Paper Recycling & By-Products

6.IV.5.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: How recycling conserves resources, saves money and reduces waste.

Subject: Science, Social Studies, Art

Materials: See list of materials itemized below

Teaching Time: Several class periods

Vocabulary: pH, contaminants, by-products, pollutants, heavy metals, distillates, wastewater treatment

Learning Objective

Students will:

- recycle paper to see the by-products of the process
- understand that by-products of all manufacturing processes pose potential environmental concerns.

Background

Paper cannot be recycled indefinitely because the fibers break down eventually. However, many grades of paper can be de-inked, cleaned and bleached; processes that allow paper to be reused as gameboards, tissue paper, ticket stubs, packaging, covers for hardcover books, insulation and animal bedding.

Although recycling paper saves natural resources and energy, pollution problems still exist in the production of recycled paper. To be recycled, waste paper must have **contaminants** removed.

Black printing inks used in newspapers are composed of about 30 percent pigment (usually carbon black) and about 70 percent petroleum-

refined oil. Colored pigments in magazines – and increasingly in newspapers – contain **heavy metals**.

New low-rub inks and laser printing cause additional problems because they are difficult to remove from paper.

The paper-making process requires large amounts of water, all of which must be cleaned of contaminants. The remaining paper sludge also must be disposed of properly because petroleum **distillates** and heavy metals can remain present in this material. Both the contaminated water and sludge must be treated in a **wastewater treatment plant** before being released into the environment.

Materials

This lesson includes a papermaking exercise. The materials needed include:

- several sheets (at least 9" x 12" [23 cm x 30 cm]) of different types of used paper (newsprint, white office paper, construction paper, envelopes)
- nylon stocking, cheesecloth or millipore filter
- *Recycled Paper & Its By-Products* worksheet
- blender or egg beater & wide-mouthed container
- pans
- large mixing spoons
- cups to scoop with
- blotters
- dishwashing detergent
- sponges or towels to soak up water
- warm water
- a place to dry paper overnight
- iron (to help dry paper)
- litmus paper

DOWN TO EARTH



It takes up to 15 years for a tree to grow big enough to make into paper. Using recycled paper for one print run of the Sunday edition of the *New York Times* would save 75,000 trees.

Source: Going Green, Puffin Books

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Questions for the Class

1. What natural resources are conserved when paper is recycled?
2. What kinds of paper can be recycled?
3. Does recycling solve all our paper solid waste problems?

Learning Procedure

1. Divide the class into small groups and have each group make recycled paper out of a different type of waste paper.
2. While making paper, students should collect the water that drains through the screen while the paper is being pressed to check it for **pollutants**. Have each group strain the collected water and sludge through a filter and examine what contaminants remain.
3. Have students use the collected water after straining and note its **pH**, color and sediment. Set samples aside (do not disturb) and repeat pH, color and sediment tests and observations after 24 hours. *(For another lesson on pH and water, see the lesson entitled, Death of a Lake.)*
4. Have each group complete the *Recycled Paper and Its By-Products* questions and discuss the results as a class.

Just Do It

Contact your local recycling center or DHEC's recycling information line

1-800-768-7248

to learn what types of paper are commercially recycled, the location of the collection centers and the proper way to bundle and separate different types of paper.

Questions on Recycled Paper and Its By-Products

1. What materials are in the sediment and sludge?
2. What is causing the discoloration of the water?
3. Is the strained water less polluted than the unstrained water? Why?
4. Should the remaining paper sludge be treated as solid waste or hazardous waste?
5. How can we reduce pollution problems?

Extension Activities

1. Visit or write a South Carolina pulp mill. Find out if the mill uses only virgin timber, a mixture of virgin timber and recycled paper, or only recycled paper. Research the pollution control methods used in paper-making plants.
2. Research new soya-based inks and their effect on paper recycling.
3. As an art project, make recycled paper from various types of used paper, such as colored construction paper, white office paper, brown paper bags, etc. Students may also add bits of leaves, grass, flowers, pinestraw, and other natural elements.

Making Paper

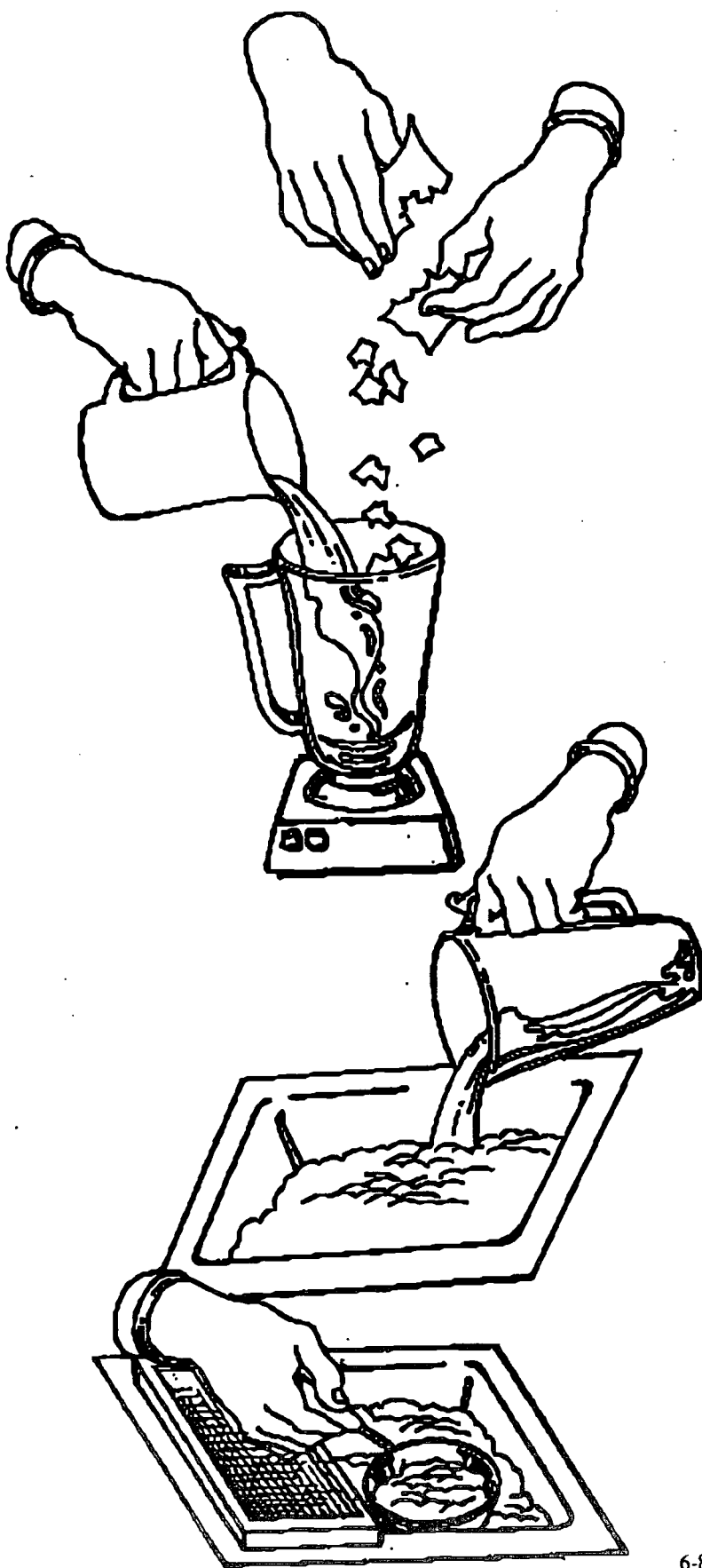
1. Tear sheets of used paper (one different type of paper for each group of students) into small strips about one-inch square. Loosely pack into blender until $\frac{1}{3}$ to $\frac{1}{2}$ full. Add warm water until blender is $\frac{2}{3}$ full.

2. Blend, with lid on, until the paper looks like oatmeal (5 to 10 seconds).

3. Empty the blender into a pan and add about $\frac{1}{2}$ inch (1.3 cm) of water for every blender of pulp, adding more or less depending upon the thickness of paper desired.

4. Scoop the pulp mixture evenly onto the screen with a cup (hold the frame over half the pan). Let the pulp drain.

OPTION: you may dip the screen *under* the pulp and pull it up so that the pulp spreads out evenly on the screen. Don't forget to let the excess water drain into the pan.

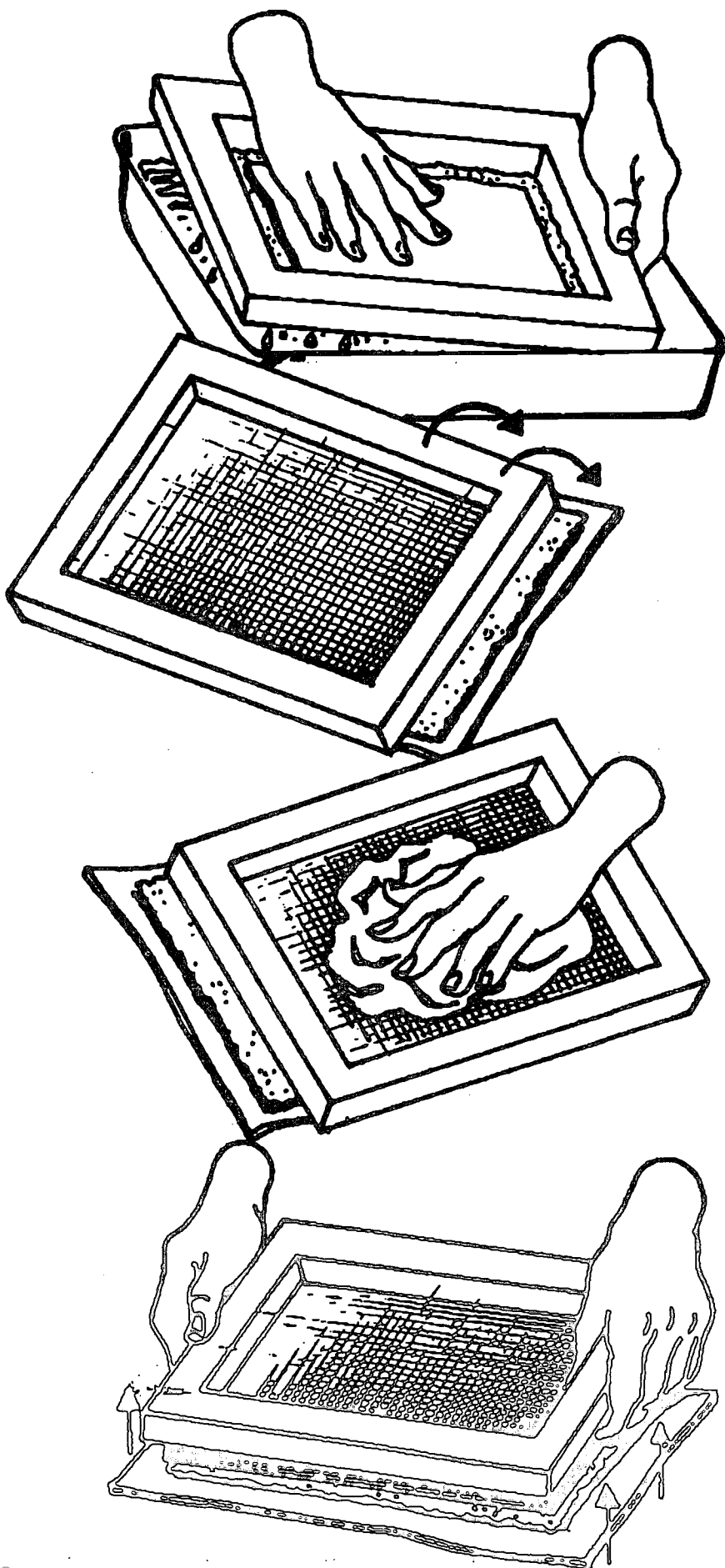


5. Place a piece of blotter paper over the wet pulp paper formed on the screen.

6. Flip the screen over so the pulp paper is between the blotter and the screen with the screen on top.

7. Soak up extra water with a sponge. This water can be squeezed out and collected along with the water in the pan.

8. Lift off the screen and place the new paper in a safe place to dry. Drying takes one or two days. Exchange blotter and dry paper towels every few hours if you want the paper to dry more quickly, or you may iron the paper to speed up the process. If you choose to iron your paper, place a sheet of paper between the new paper and the iron.



Life Cycles

6.IV.6.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 - 8

Focus: Where do things we use come from and where do they go?

Subject: Language Arts, Social Studies, Science

Materials: Objects made of one material (each student brings an item to class), construction paper, markers, crayons, etc.

Teaching Time: One to two class periods

Vocabulary: Life cycle, natural resource, reuse, recycle, transportation, energy, recycle

2. Have students trace all the steps needed to **recycle** the product into another object or to extend the item's life cycle. Illustrate the life cycle.

3. Discuss the steps required to produce the things we use each day. How many times is the object **transported** in its lifetime? By what? Using what **energy** source as fuel? Is the object easily **reusable**? Is it easily recyclable? What are the environmental effects of producing and transporting the object? See *From Where, To Where* (included with this lesson).

Learning Objective

Students will:

- trace objects from their source, to the consumer, and back again to evaluate use and reuse of resources.

Extension Activities

1. Trace the life cycle of a pencil or other commonly used, inexpensive object made from several different resources. Is a pencil easily recyclable?
2. Trace the life cycle of a newspaper. Then trace the life cycle of newspaper that is recycled and/or reused a few times. What is saved by the recycling?
3. Compare the life cycles of two items you could use for the same purpose. (Paper towel vs. washable dish cloth.) Determine the one with the least wasteful life cycle.

Background

Everything we make, use and throw away comes from and returns to the earth. Often, the level of waste associated with an item can be evaluated by examining the **life cycle** of the item: what **natural resource** it is made from; how it is made, used, and treated after use.

Learning Procedure

1. Ask each student to bring to class a common household object made from only one material, such as a rubber eraser, glass jar, piece of paper or plastic bag. Each student will identify the natural resources used and the steps taken to make the object and to deliver it to the consumer.

Just Do It

Don't cut an item's useful life cycle short!
Always look for one more way to use an item.
For example, donate old clothes
and toys to thrift stores or
cut up old t-shirts to use as polishing cloths.

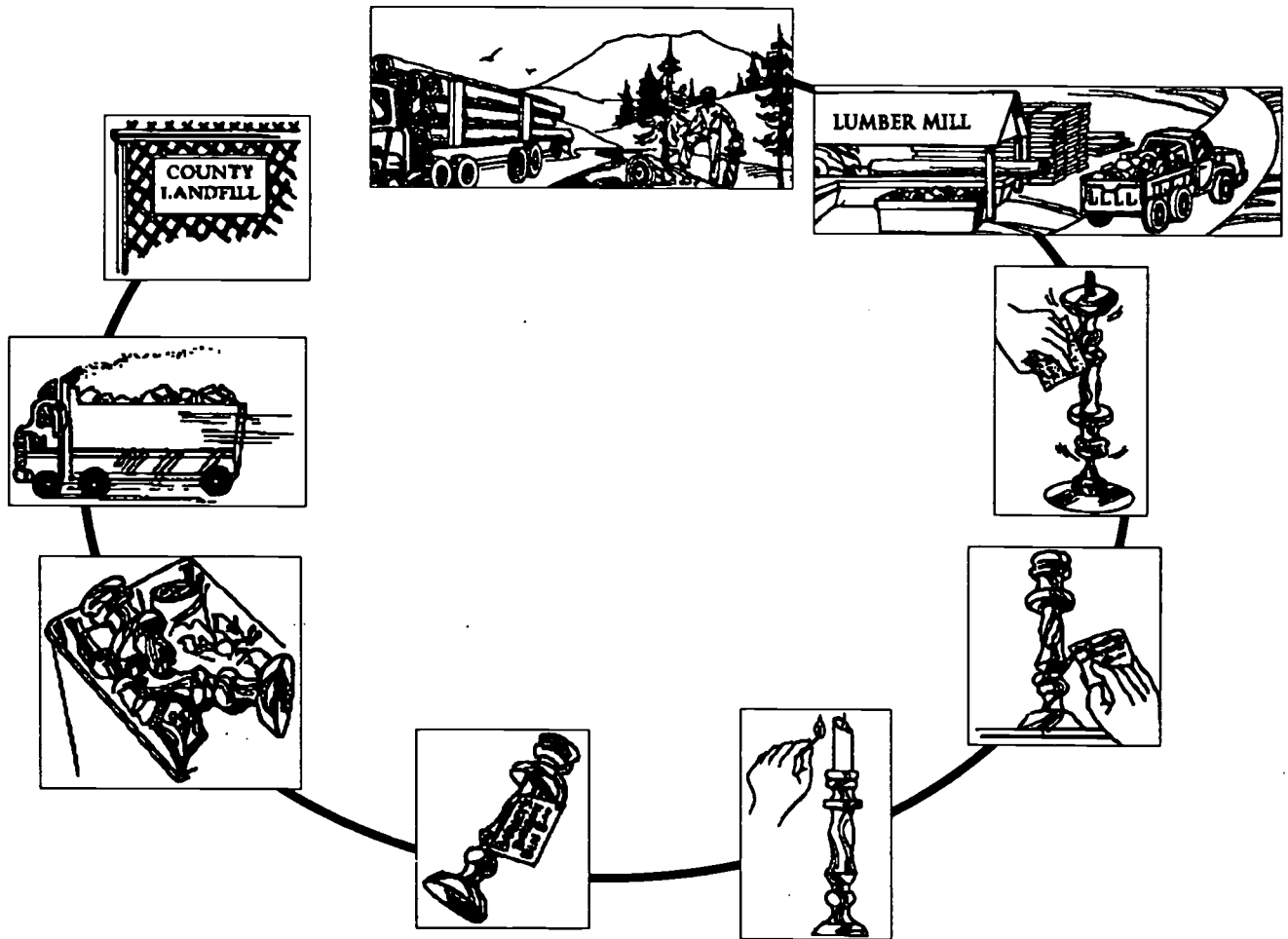


Mt. Everest is the world's tallest mountain, but it is also the world's most elevated trash dump. Up to 50 tons of garbage has been tossed along the sides of the mountain since 1953. In 1993, \$740,000 was spent on an expedition to attempt to clean up the mess.

Source: 1994 *Information Please Environmental Almanac*

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From Where, To Where?



A tree is cut down by a logger.
A truck hauls the log to the mill.
The mill processes the log into furniture-grade wood.
The furniture factory buys the wood.
A truck hauls the wood to the factory.
The furniture factory makes the wood into candlesticks.
A truck hauls the candlesticks to a distributor's showroom.
The distributor sells the candlesticks to a retail store.
A truck hauls the candlesticks to the retail store.
A consumer buys the candlesticks from the store.
The consumer transports the candlesticks home and uses them.
The consumer tires of the candlestick design and transports them to a thrift store.
A consumer purchases the candlesticks from the thrift store.
The consumer transports the candlesticks home and uses them.
The consumer breaks one of the candlesticks and tosses it into the trash.
The trash is picked up and hauled to a transfer station where it is compacted with other wastes.
The wastes are hauled to a landfill.
The wastes remain in the landfill.

Recycling: It's An Energy Issue

6.IV.7.

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Energy awareness, economics of recycling

Subject: Science, Math

Materials: See list below

Teaching Time: One class period

Vocabulary: Btu, energy, direct energy, indirect energy, embedded energy, recycling, cullet, virgin materials, HDPE, PET

Learning Objective

Students will:

- understand embedded energy
- identify how energy becomes embedded in a product
- calculate the percent of energy saved when comparing the energy consumed by processing virgin materials versus recycling various materials
- conclude that recycling saves both direct and embedded energy.

Background

According to the Environmental Protection Agency, in the year 2000 the U.S. will bury or burn:

- 11.4 million tons of newsprint
- 16.2 million tons of corrugated cardboard
- 10.8 million tons of glass packaging
- 8.2 million tons of plastic packaging
- 1.5 million tons of aluminum packaging.

This totals 48.1 million tons of buried or burned solid waste, a fraction of the total 280 million tons of commercial, residential and institutional waste generated in the U.S. each year. (See the Resource section for South Carolina's waste stream components.)

United States' energy consumption has increased an average of 1.1 percent every year since 1970.

If this 48.1 million tons of material were recycled instead of being buried or burned, the United States would save the equivalent of 10.1 billion gallons of gasoline. That is enough gasoline to power 15.4 million cars for one year. (*assuming 18.3 miles per gallon and 12,000 miles per year*).

In addition, the use of recycled materials results in the reduction of water use, water pollution, air pollution and energy consumption. Yet, the U.S. currently only recycles about 14 percent of the 280 million tons of garbage it generates each year. (*Source: 1993 Environmental Almanac*)

The energy used to manufacture a product is a **direct energy** cost. But there are indirect energy costs, too. The energy used to obtain raw materials, for transportation, distribution and even the disposal of an item contributes to **indirect energy** costs. Direct energy costs plus indirect energy costs are referred to as **embedded energy**. (*The total amount of energy a product uses in its "life."*) Both direct and indirect energy costs can be reduced through recycling. The *Energy in Waste* scenarios (included with this lesson) provide estimates of how much embedded energy can be saved by recycling certain products.

DOWN TO EARTH



Although only 5 percent of the world's people live in the United States, the nation accounts for 25 percent of the world's energy consumption.

Source: 1993 Environmental Almanac

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Materials

Overhead transparency of *The Environmental Effects of Resource Use* or copies for a group of students, copies of the worksheet *Energy in Waste Analysis*, one copy of the *Energy in Waste* scenarios for each group.

Learning Procedure

1. Write "energy" on the board. Ask students for examples of different kinds of energy (*light, heat, mechanical, chemical, nuclear, and electrical, etc.*). Write "direct energy" and define it as the energy it takes to manufacture a product or provide a service.

2. Write "indirect energy" on the board and help students define it as the energy used to make and move products that is not directly involved in the production process.

3. Write "embedded energy" on the board. Ask students to develop a definition of the term. Remind students that all matter contains energy. Once something is moved or manufactured, it also has embedded energy. The amount of embedded energy depends on the amount of processing involved. Point out that embedded energy costs are very useful when scientists are evaluating different processing or manufacturing options.

4. Project the overhead, *The Environmental Effects of Resource Use*. Discuss each of the three steps involved in resource use. Have students identify how direct and indirect energy is used during each step. Point out the environmental effects of each step. Leave the overhead projector on so students can use the overhead to fill out the worksheet.

5. Divide the class into groups of four students. Give each group a set of the *Energy in Waste* scenarios. Give each student a copy of the worksheet *Energy in Waste Analysis*.

6. Instruct students to read each scenario and fill out the chart for each category of waste. Each student should calculate the percentage of energy savings and identify sources of embedded energy (*direct and indirect*) in both new materials and recycled

stock. (An alternative is to have one student in each group act as the reader while the other students record the information.)

7. Review the procedure for calculating percentage.

STEP 1:

$$\frac{\text{(Energy costs for new materials)}}{\text{(Energy costs for recycled materials)}} = \text{(Energy Saved)}$$

STEP 2:

$$\frac{\text{(Energy saved)}}{\text{(Energy cost for new materials)}} \times 100 = \text{(\% of Energy Saved)}$$

(For example: To make copper from ore requires 280 million Btus per ton; to make copper from scrap requires just 10 million Btus per ton. This is a savings of 270 million Btus per ton ($280 - 10 = 270$) and $270 \div 280 \times 100 = 96\%$ savings. A British thermal unit [Btu] is the amount of heat energy required to raise the temperature of one pound of water by one degree Fahrenheit.)

8. After students have completed their worksheets, have them write a conclusion by comparing new materials versus recycled stock. Their conclusions must be based on their analysis of the embedded energy used or saved.

Evaluation

1. The students will have correctly calculated the percentage of energy saved for five materials:

(*paper = 67%; glass = 6%; PET plastic = 88%; HDPE plastic = 78%; aluminum = 95%*)

2. Based on the data from the worksheet, students will conclude that recycling saves large amounts of embedded energy.

Questions for the Class

1. How much embedded energy is there in a car?

Have students discuss the raw materials typically contained in a new car. Have students make a mural showing the embedded energy in each of the materials as they flow together to form a car.

2. Convert the energy savings from Btus to other forms of energy by using the following factors:

- one gallon of gas has 124,000 Btus
- one kwh of electricity has 3,400 Btus
- one ton of coal has 25,400,000 Btus

Extension Activities

1. Energy use and global environmental issues such as the "greenhouse effect" are closely linked. Have students work together to develop a chart that shows how energy use, recycling, energy and global warming and the greenhouse effect are linked. For more information, see the chapter, "All This, and CO₂," from the book, *50 More Things You Can Do To Save The Earth*. Make arrangements for the chart to be displayed in the cafeteria.

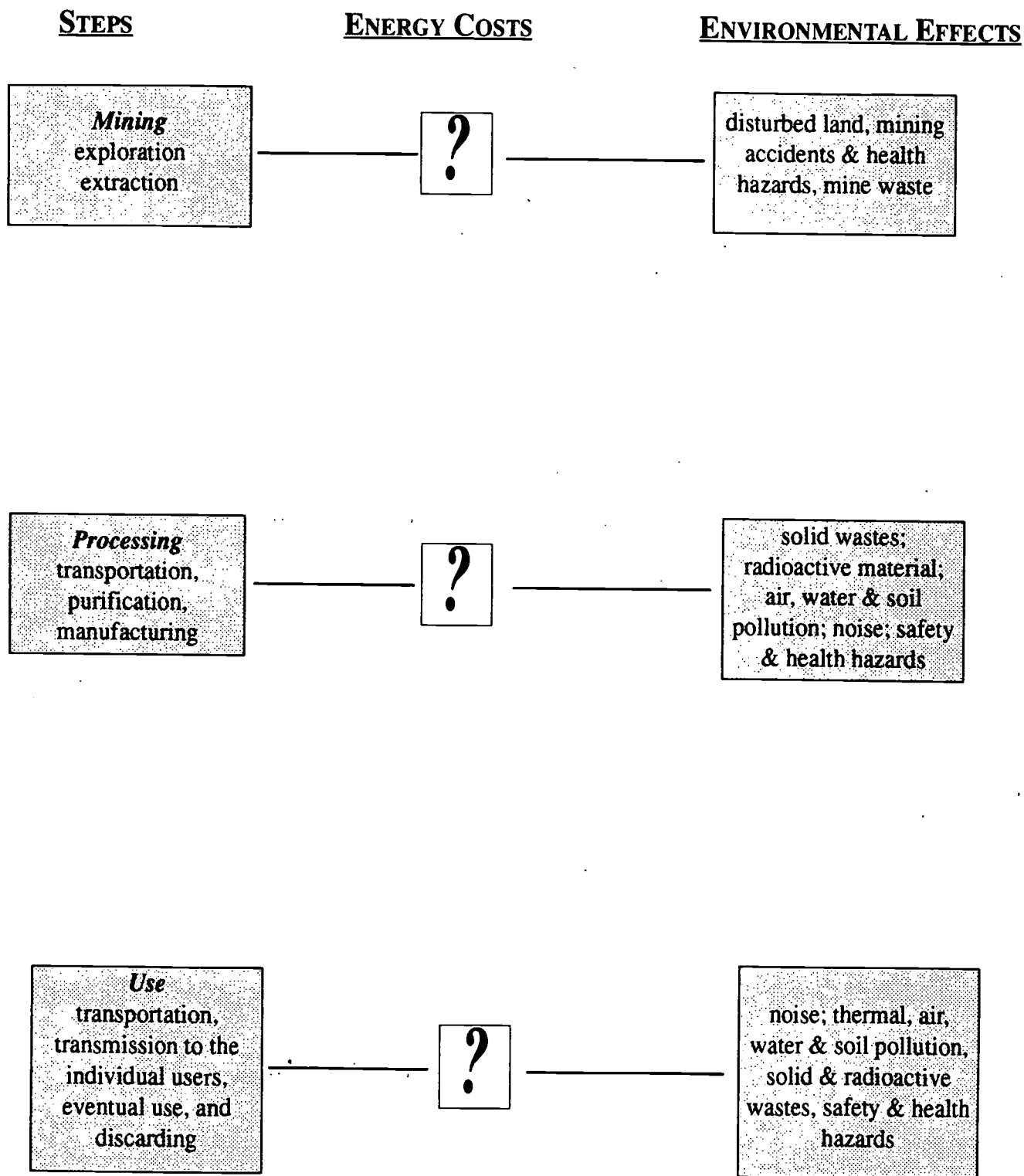
World Primary Energy Consumption

(in quadrillion Btus, 1991)

North America	863.1
USA	780.8
Canada	82.3
Latin America	161.3
Western Europe	553.8
Former Soviet Union & Central Europe	642.8
Middle East	94.6
Africa	87.1
Asia & Oceania	720.2
World	3,123.0

Source: *BP Statistical Review of World Energy*
(British Petroleum, London, June 1992,) pg. 34.

The Environmental Affects of Resource Use



Energy In Waste Analysis

Materials	(Energy Costs in Millions of Btus per Ton)							Sources of Embedded Energy			
	Energy Costs (New Materials)	—	Energy Costs (Recycled)	=	Energy Saved	÷	Costs (New)	x 100 =	% Energy Saved	New Materials	Recycled Materials
Paper								100			
Glass								100			
PET Plastic								100			
HDPE Plastic								100			
Aluminum								100			

Conclusions:

Energy In Waste

- **Paper** makes up 37.6 percent of South Carolina's solid waste stream.* Depending on the kind of paper being made and mill efficiency, using recycled stock reduces energy use by 25 to 75 percent when compared to using virgin pulp stock. To make a ton of newsprint from virgin pulp requires 30 million Btus; using pulp from used newsprint requires only 10 million Btus per ton.

- **Plastics** make up 9.3 percent of South Carolina's solid waste stream.* These are ideal candidates for recycling because they are literally made of fossil energy — about 30 percent oil and 70 percent natural gas. Soft drink bottles (made of polyethylene terephthalate or **PET**) cost about 98 million Btus per ton to make. Bottles made of recycled PET needs only about 12 million Btus per ton. Another high-use plastic that has great potential for recycling is high density polyethylene (**HDPE**) used to make such items as milk jugs and detergent bottles. The United States produces about three times more HDPE than PET. Recycling one ton of HDPE saves about 76 million Btus. A ton of virgin HDPE "costs" about the same as a ton of PET.

- **Glass** makes up 6.6 percent of South Carolina's solid waste stream.* Recycling glass usually begins with color separation followed by grinding the glass into small pieces called **cullet**. Energy is saved because the cullet melts at lower temperatures than new materials. To make a ton of glass from new materials requires 16 million Btus per ton; less than 15 million Btus are needed to make a ton of glass from cullet. The energy needed for throwaways is 58,000 Btus per gallon.

- **Aluminum** and other metals make up 8.3 percent of South Carolina's solid waste stream.* About 95 percent of the energy needed to produce aluminum from bauxite ore is saved by substituting aluminum scrap. Estimates on the energy costs for extracting a ton of aluminum from bauxite average 250 million Btus per ton; only 12.5 million Btus are needed to produce a ton from scrap. Recycling other metals produces similar energy savings.

* Percentages calculated by weight. Source: *South Carolina Solid Waste Management Plan, 1995*

The Bottom Line of Recycling

6.IV.8.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 – 8

Focus: Recycling makes good economic sense.

Subject: Social Studies, Economics

Materials: Chart included with lesson

Teaching Time: 30-minute discussion

Vocabulary: Recycling, market, demand, profit

nearby to recycle the materials. For recycling centers to exist, there must be a market, in other words there must be: 1) a **demand** for the recycled materials the center collects (consumers purchasing more recycled materials creates this demand), and 2) a chance to make a **profit** running the recycling center (or in the case of municipal recycling programs, a chance to break even to pay for the program).

Learning Objective

Students will:

- see that financial reward – the profit motive – plays an important role in making recycling happen
- determine that, for recycling to be effective, there must be a market for recyclable materials and for recycled goods.

In many areas of the state, recycling is available. For example, areas of downtown Columbia offer curbside recycling along with regular trash pickup. In other areas of our state, recycling centers accept drop-offs of recyclable materials.

In some states recycling is mandatory. For example in Oregon, by law, all communities with a population of 4,000 people or more must have some form of curbside recycling.

Background

Education and a sense of responsibility for the environment increase participation in **recycling**, but financial reward is also a catalyst to action. Saving recyclables is useless though if there is no place

What Would You Do

A - If I Asked You

1. Wear white gloves to school all day
2. Eat a raw onion
3. Stop drinking soda for one month
4. Help an injured person and miss a concert
5. Pick up litter on weekends
6. Recycle everyday

B - If I Paid You

DOWN TO EARTH



Would you pay more for an electric car with an emission level of zero? In the very near future battery-powered cars will be available in the United States. Call Ford at 1 800-ALT-FUEL, or GM at 1 800-25ELECTRIC for more information.

Source: *GreenWatch*, *Good Housekeeping*, Dec. 92

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Questions for the Class

1. Do you know what is recyclable in your area?
2. What is the best way to motivate people to recycle and to operate recycling centers?

Learning Procedure

1. Make the *What Would You Do* chart on the board or overhead similar to the one included with this lesson. For discussion purposes, you may set a limit for the column, If I Paid You, such as \$20.

2. Record student responses to column A, then column B. For example:

- a. Would you wear white gloves to school all day if I *asked* you?
- b. Would you wear white gloves to school all day if I *paid* you?
- a. Would you eat a raw onion if I *asked* you?
- b. Would you eat a raw onion if I *paid* you?
- a. Would you stop drinking soft drinks for a month if I *asked* you?
- b. Would you stop drinking soft drinks for a month if I *paid* you?
- a. Would you help someone who was hurt and miss a concert if I *asked* you?
- b. Would you help someone who was hurt and miss a concert if I *paid* you?
- a. Would you pick up litter on weekends if I *asked* you?
- b. Would you pick up litter on weekends if I *paid* you?
- a. Would you recycle everyday if I *asked* you?
- b. Would you recycle everyday if I *paid* you?

You may want to create your own set of questions concerning local issues.

3. **Ask:** What differences do you see between column A & B? **Why?** **Ask:** If we want people to recycle, what is a good way to get them to do it? Is it enough for people to be educated about the benefits of recycling? Or do we need to provide an economic incentive?

What about the people who run the recycling centers: Why do they do it? What do these people need to be able to keep running their businesses? What would happen if they had no one to sell their recyclables to?

What has to exist in order for a recycler to sell recyclables? (*There has to be a market demand.*)

If sufficient markets for recyclables do not now exist but the public demands that more waste be recycled rather than dumped in the landfill or incinerated, should the government help create markets for recyclables? How?

What are some things government can do to stimulate recycling? Are there problems if the government gets involved? What do you think the government should do?

Extension Activity

Invite a representative from the recycling industry to visit your class and explain the business. For a current copy of *South Carolina Recycles*, a directory of recycling programs and markets in the state, contact S.C. DHEC at 1-800-76-USE-IT. Plan a series of interview questions for your guest.

- What recyclables does the business handle?
- Does the business pay for these materials? If so, how much?
- How does the business make money?
- Where do the materials end up? What do they become?

Making a Compost Pile (or) Lawn Lasagna

6.IV.9.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 - 8

Focus: Composting, organic gardening

Subject: Science, Biology, Horticulture, Vocational Agriculture, and Home Economics

Materials: Organic materials containing carbon such as dead leaves, tea leaves, and coffee grounds; materials containing nitrogen such as green grass clippings, green leaves; soil

Teaching Time: Several class periods over a couple of weeks

Vocabulary: Compost, biodegrade, carbon, humus, decomposition, nitrogen



Learning Objective

Students will:

- learn the basics of composting
- understand how composting reduces yard and garden waste
- learn the basics of soil construction.

Background

Composting can significantly reduce the volume of residential solid waste.

Composting is the natural decomposition of organic materials through biological activity. Naturally occurring bacteria break down leaves, grass clippings, kitchen scraps and other organic wastes into a material called **humus** or **compost** that looks, feels and smells like soil. A traditional means of reducing and recycling organic wastes, composting is receiving renewed attention.

There are three main types of composting.

- Nature's recycling – This occurs naturally

on forest floors as fallen leaves and tree limbs **biodegrade** into rich humus. Nature replenishes itself this way without human intervention and returns nutrients to plants and trees.

- **Backyard composting** - This has been practiced by gardeners for years, turning garden and yard clippings into a nutrient rich soil enhancer. Organic materials are usually collected in a pile or bin in the backyard. Air, water and heat help break down materials into humus for future planting.

- **Municipal composting** - This is a new and exciting application of traditional composting. Thousands of communities already compost their leaves, grass and yard trimmings. These communities have special trucks pick up the yard wastes and take it to a central composting site where it is turned into humus that can be sold or given away to gardeners in the community. Unlike landfills, a composting site can be continually reused without ever reaching capacity. If properly constructed and managed, municipal composting is sanitary and produces no offensive odors.

South Carolina has 63 composting and wood chipping/shredding facilities.



One of the world's largest composting piles, the Netherland's Waste Treatment Company produces about 125,000 tons of compost a year. This is sold for farm and garden uses.

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According to figures from the 1995 South Carolina Solid Waste Management Plan, 15.9 percent of our solid waste is lawn and garden waste. In many South Carolina communities, yard wastes are collected and taken to local composting facilities. In most areas, the demand for the rich compost material is greater than the amount of compost available.

Yard wastes do not belong in our landfills. Because of the construction of today's modern, sanitary landfills, waste – even yard clippings – do not biodegrade in the landfill. The South Carolina Solid Waste Policy and Management Act forbids the disposal of yard waste and land-clearing debris in municipal landfills after May 27, 1993. (For more information on composting, see the Resource section.)

Learning Procedure

Version One: Building a Hot Compost Pile

Hot piles are useful for composting food and yard wastes together. The advantages of hot compost piles are: they are free of pests, kill soil diseases and weed seeds, and produce compost quickly.

1. Using the following instructions, build a hot compost pile. Gather all the materials needed to make a pile at least three feet cubed. Use both green and brown materials. Green materials provide **nitrogen** needed for **decomposition** and include fresh grass clippings and yard trimmings. Cottonseed meal, blood meal and manure are also high in nitrogen. Brown materials provide **carbon** and include dead leaves, straw and sawdust. Strive for a 30 to 1 carbon to nitrogen ratio. (*Alternating layers of brown and green materials of the same thickness produces this ratio.*)
2. If possible, shred or chop materials.
3. Start building the pile with a 4 – 6 inch (10 – 15 cm) base of (brown) carbonaceous material. If no food wastes are included and the pile is going to sit for more than a few weeks, use coarse material such as corn stalks for this base layer to let air into the pile. Moisten materials.
4. Next add a 4 – 6 inch (10 – 15 cm) layer of high

nitrogen materials. If the greens are not fresh, sprinkle on a small amount of cottonseed or blood meal, poultry manure, or other high nitrogen source. High nitrogen wastes such as fresh grass clippings or food should be used in 4 – 6 inch (10 – 15 cm) layers. Food waste should not include meat, fats, or oils because they attract scavenging animals. Mix green and high nitrogen materials.

5. If you choose to build a bin to hold the compost, fill the bin. Alternate layers of green and brown materials, adding water and extra nitrogen as needed until the pile is three to four feet high.
6. Cover the pile or close the bin, if extreme wet or dry climatic conditions require it. Regularly monitor the temperature in the pile's interior. It should peak between 120 to 160 degrees Fahrenheit (49 to 71 degrees Celsius). (In winter, it will steam.)
7. When the temperature increases to between 120 and 160 degrees Fahrenheit (49 and 71 degrees Celsius), turn the pile. Take materials from the outer edges and top of the pile and put them at the base and in the middle of the new pile. Materials from the center should be on the outer edges and on top of the new pile.
8. Monitor the temperature in the new pile.
9. In about a week, the temperature should peak. Turn the pile again. After another week, the compost should be finished.

Version Two: Changing the Conditions

1. Using the layering and turning method described in Version One, start five experimental compost piles in bins or five-gallon buckets, four of which have holes drilled in the sides.
The five experimental conditions:
 - a) Low in nitrogen
 - No high nitrogen materials
 - b) Not enough moisture
 - Don't water and exclude wet components
 - c) No air (anaerobic)
 - Use bucket without holes
 - Do not turn
 - d) No carbonaceous material

e) Good compost pile

- Proper 30-to-1 ratio of brown (carbonaceous) to green (nitrogenous) materials
- Layer materials
- Keep moist
- Turn regularly

2. Keep a daily record of the temperature of each pile.

3. After three or four weeks, discuss the results.

Ask: What are the necessary components of a good compost pile? Why does the good compost pile break down wastes faster than the others? How do the components of a compost pile work together to decompose materials? How is recycling within the compost pile like the nitrogen cycle and other natural cycles in our biosphere? *(The nitrogen cycle is the continuous, cyclic progression of chemical reactions in which atmospheric nitrogen is compounded, dissolved in rain, deposited in the soil, assimilated and metabolized by bacteria and plants, and returned to the atmosphere by organic decomposition.)*

- Where is composting occurring naturally?
- What are the environmental impacts of dumping compostable, organic wastes in landfills? *(Decomposing organic material produces methane gas, which can be explosive.)*
- Why does composting make sense? *(Composting can significantly reduce waste volumes, reduce the production of methane gas, provide a beneficial soil conditioner by recycling natural elements and nutrients.)*

Questions for the Class

1. What is composting?
2. What are the necessary ingredients for a good compost pile?
3. How does composting promote recycling?
4. How can composting reduce waste?
5. What is the proper compost mix of brown (carbonaceous) materials and green (nitrogenous) materials?

How the Compost Pile Grows

Soil: contains microorganisms that help decomposition.

Organic Wastes: leaves, food scraps and grass clippings. Wastes should be varied including materials with high carbon and high nitrogen content. By alternating these materials you create good environmental conditions for decomposition.

Nitrogen: many of the organisms responsible for decomposition need nitrogen. Nitrogen is found naturally in many organic wastes, such as manure and green grass clippings.

Carbon: brown materials such as dead leaves, straw and saw dust.

Worms: they eat waste, helping to break it down. Worms make droppings that enrich the soil and tunnel through and aerate the waste. As the worms eventually die, they become part of the compost.

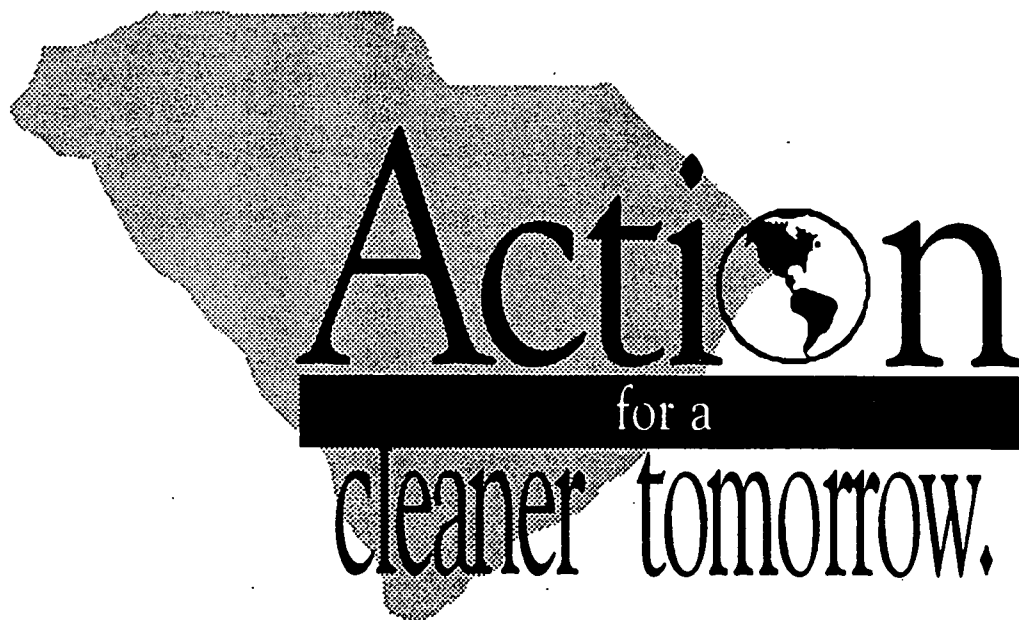
Water: necessary for normal functioning of life. Too much water in a compost pile may make it soggy and slow to decompose.

Air: the biological activity of fungi, bacteria, small insects and organisms results in decomposition. Most biological processes require oxygen.

Time: decomposition takes time. To speed it, aerate your compost pile every few days.

Heat: heat is produced by chemical reactions resulting from increased biological activity that occurs during decomposition. Heat helps sanitize compost by killing certain organisms such as weed seeds and harmful insect larvae.

Mass: to generate enough heat for optimal decomposition, the pile must contain at least one cubic meter of organic material. The temperatures generated in a small pile are different than those generated in one that is larger.

A stylized, textured map of South Carolina serves as a background for the title. The word "Action" is written in a large, serif font, with a globe icon integrated into the letter "i". Below "Action" is a solid black horizontal bar. Underneath the bar, the words "for a" are written in a smaller, lowercase serif font, followed by "cleaner tomorrow." in a larger, lowercase serif font.

Action for a cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Help Wanted

6.IV.12

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 - 8

Focus: Environmental occupations, advertising


Subject: Social Studies, Language Arts

Materials: Copies of help wanted display ads from waste management or environmental trade journals (these can be found in most county libraries or you may take students to the library to do their own research), colored markers and paper

Teaching Time: One or two class periods

Vocabulary: Advertisement, logo, headline, body copy, trade publications

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Learning Objectives

Students will:

- identify potential occupations and educational requirements for careers in environmental fields
- identify the major parts of a display advertisement
- prepare an advertisement for a waste management publication.

Background

As the number of people living in South Carolina grows and the amount of waste each person produces grows, there will be a corresponding need to employ people in the waste management industry and in environmental positions in a host of industries.

The competition in the waste management industry is growing. Many of the small "mom and pop" recycling shops are going out of business and large corporations are becoming more involved in comprehensive waste management programs. South

Carolina cities and counties are literally spending millions of dollars on waste and protecting the environment.

Green professions are in demand. Manufacturing, production and management strategies are being revamped. Companies are examining every aspect of business from the extraction of raw materials to the disposal of the final product. This includes purchasing, public relations, marketing, financial management, research and development, accounting, sales, personnel, training and strategic management.

- Environmental consultants are regularly called in when companies are making transitions.
- Banks need environmental investors and researchers.



Canada's Green Plan commits the nation to protecting a full 12 percent of its land and water by the year 2000.

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- Businesses are needed to create new technology for clean-ups.
- The petroleum industry needs environmental engineers, biologists and consultants to perform studies on the environment.
- Chemical firms also need environmental engineers as well as compliance administrators and product and marketing managers.
- Organic foods have created a niche in industry. Experts are needed for pest management, organic gardening, retailing of organic food and mail order sales.
- Environmental lawyers are needed.
- Insurance companies have had to acquire the cost of cleaning up wastes left by firms carrying their policies.
- Environmental regulators, such as those at S.C. DHEC and the U.S. EPA, enforce laws.

These are just a few examples of the edge given to those in the job market that are environmentally educated. There are many more.

As employment opportunities grow, the need for people with special skills also grows. These specialists often advertise their services and expertise in national business newspapers and trade publications that are targeted to specific audiences.

Learning Procedure

1. **Ask:** Do you know someone who works in an environmental profession? (Have them explain what the person does.) **Ask:** Have you ever considered an environmental career for yourself? How would you research what kind of jobs are available in environmental professions?
2. Explain to the class that one way to find out is to review trade publications. **Trade publications** are magazines and newspapers written specifically to professionals working in a single industry.

Give students copies of the Help Wanted ads you have obtained from these publications or plan a trip to the local library. (You'll need to call the librarian in advance to ensure that they have copies of several environmental trade journals such as *Waste Age*, *Recycle*, *Garbage*, and *Chemical Week*)

3. Have students identify 10 different environmental jobs by reviewing the advertisements in these publications. Have them note the name of the company, the type of business, the type of job, and the location of the company.

4. Discuss the format of the display advertisements (*display ads are the large boxed ads with art, not the line-by-line ads*). What things do the advertisements have in common? (*logo, headline or large type, body copy, art, borders, company name, address and phone*) What makes one advertisement more appealing than another? Develop a class checklist of items that should be included in successful help wanted advertisements.

5. Tell the students they will be creating display advertisements for a national circulation waste management magazine. Each advertisement should have a logo, a description of the services their company offers and the kinds of positions that are available. Students should use different colors in their advertisements.

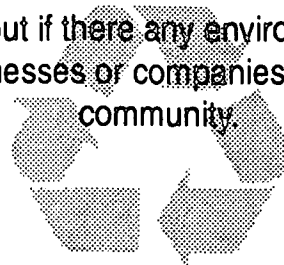
6. Distribute the paper and colored markers. Have students decide create an advertisement. When the students have completed their advertisements, tape them to the wall or board and have students critique each others' work. They should use the checklist to be sure each advertisement contains all the essential information.

Extension Activity

Arrange for a guest speaker from a local waste management firm or government agency to visit your class to discuss employment opportunities, educational requirements and job qualifications.

Just Do It

Find out if there are any environmental businesses or companies in your community.



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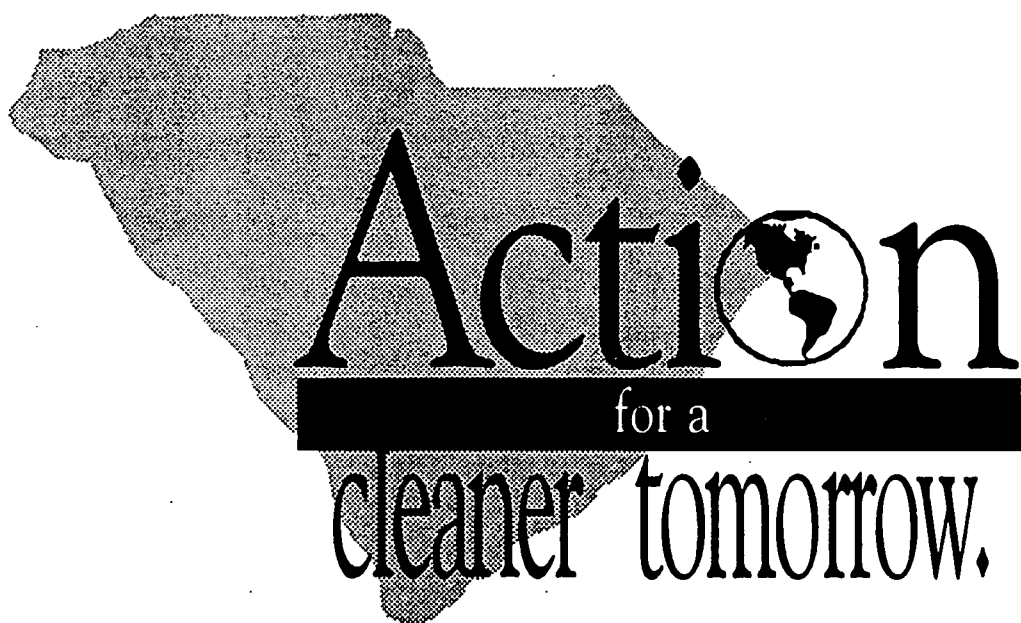
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Ins & Outs of a Worm's Life

6.IV.13.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 – 8

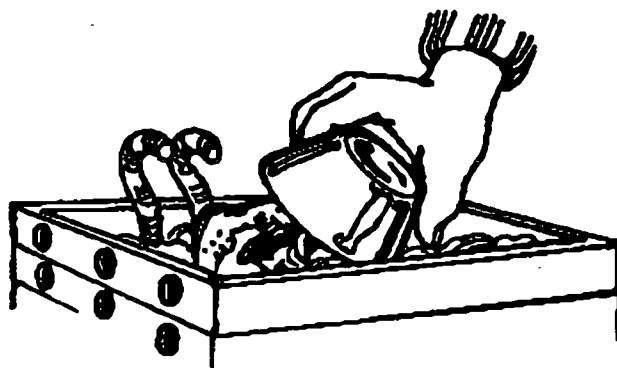
Focus: Household waste, waste reduction, composting

Subject: Science

Materials: See list

Teaching Time: Extensive ongoing project

Vocabulary: Anaerobic, worm castings, biodegradation, composting



Learning Objective

Students will:

- discover a beneficial, low technology way to reduce household waste
- understand the natural process of **biodegradation** and soil production
- see how to improve soil through worm composting
- learn what a landfill does
- learn the benefits of composting.

Background

In South Carolina, food waste constitutes 6.7 percent of the solid waste stream. (Source: *South Carolina Solid Waste Management Plan, 1994, S.C. Department of Health and Environmental Control.*)

When we throw food scraps into the garbage, we turn a resource into a liability. At significant financial and environmental cost, waste has to be picked up, transported, and buried or burned. Composting our kitchen waste provides an alternate use for kitchen waste and creates rich soil.

Redworms, *Eisenia foetida*, in backyard worm bins are used to process kitchen waste into high quality garden compost. NOTE: Properly constructed and maintained, worm bins *do not* give off an offensive odor. For more information on earthworms, see the article "Getting Earnest About Earthworms," by Richard Conniff, *Smithsonian Magazine*, July 1993.

Worm bins provide the following benefits:

- reduce household waste
- save garbage disposal costs
- produce an excellent soil amendment
- provide worms for fishing
- demonstrate one of the most important natural processes: biodegradation and soil production.

Materials to make a composting worm bin

- Wooden box (24" x 42" x 16") (61 cm x 106.5 cm x 40.5 cm) Although construction plans for this box are included with this lesson, alternatives include using a polystyrene ice chest or an apple crate with screen covering the inside of the box or any container in which you can drill holes
- Paper
- Water



On average, an acre of land contains more than 3 million earthworms. And every gram of compost contains a billion organisms.

Source: *50 More Things You Can Do To Save The Earth*

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PAGE
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- Dirt
- Redworms (*Eisenia foetida*)
- Calcium carbonate (egg shells)
- Food waste (no meat or meat by-products!)

Learning Procedure

1. Ask the school's shop class to build a 24" x 42" x 16") (61 cm x 106.5 cm x 40.5 cm) wooden box. See the construction plans included with this lesson.

OPTION: Select a similar sized alternative box such as an apple crate or heavy shipping carton. You can use wood, metal, or other containers, as long as they are not filled deeper than 12 inches. A piece of heavy duty plastic may be used as a cover.

Nine to 12 holes should be drilled into the bottom and sides of the box. The holes provide air for the worms. A cookie sheet or plastic layer should be placed under the box to catch any debris or water falling through the holes.

2. Discuss with the class the impact of food wastes on the solid waste stream. Discuss alternative methods of handling food wastes. Introduce the idea of using redworms (*Eisenia foetida*).

3. You will need one pound (454 g) of redworms for the bin. Ask the students to look for and collect redworms (not nightcrawlers). Hints for where to look: barnyards under mulch, in compost piles, under decomposing lumber. You may need to supplement the red worm find by obtaining some from a commercial grower. Look in the *Yellow Pages* under Agricultural Suppliers.

4. Set up your worm bin. For a 4-cu.ft. (1 cubic meter) bin, bury four pounds of food waste in the bin each week, making sure to rotate the location of the burial (*mentally dividing the bin into nine squares would probably be helpful*).

Generally, for worm bins, *for each cubic foot (cubic meter) of bin*, you need 1.5 pounds (680 g) of bedding, 1 gallon (\pm 3.5 liters) of water, 1 pound (454 g) of garbage per week, 4.5 ounces (128 g) of redworms, a bit of soil, and calcium carbonate. For a 4-cu.-ft. (1 cubic meter) worm bin you will need:

- 1 box filled no deeper than 12 inches (to prevent **anaerobic** conditions from developing)
- 1 room or space with a temperature between 55°F and 77°F (13°C and 25°C)
- 6 pounds (2.7 kg) of paper for bedding
- 1-2 handfuls of soil (optional)
- Several eggshells
- 1 pound (454 g) of *Eisenia foetida* (redworms)
- 4 pounds (1.8 kg) of food waste per week

Half-size bins are also effective; they require half the amount of food and materials.

5. Shred the paper by tearing it into strips about 2-inches (5 cm) wide. Put the paper in a bucket, and slowly pour water in while fluffing the paper occasionally. Let the paper segments drip until dripping subsides. Put wet strips of paper in the worm box, and sprinkle in several eggshells (for worm reproduction).

6. Gently place the worms in the box, leaving the top open until the worms burrow down. Close the lid or cover with a black plastic sheet. (*Since worms do not react to red light, a red plexiglass side panel or lid would allow direct observation of worm activity.*) Bury food in the box each week, rotating the burial location.

Some of the foods that will work well in the worm bin are bread, corn stalks, egg shells (a good source of calcium carbonate), grass clipping, leaves, saw dust, spoiled fruit and vegetables, vegetable peelings, clothes dryer lint, citrus rinds, evergreen needles, hay or straw, twigs, weeds, coffee grounds, discarded houseplants and flowers, manure, garden waste, hedge clippings, used potting soil, and wood chips.

Avoid putting plastic, bottle caps, rubber bands, sponges, aluminum foil, or glass in the box. Fruit flies can be avoided by burying the food waste completely.

7. The worm bin needs little routine maintenance. Depending upon the desired outcome, the bedding should be changed every three to six months. After three months, one will find the number of redworms is high; after four months, the number of redworms

will still be high, and the quality of compost will be fairly good; after six months, many redworms will have died, but the quality of the compost will be very good. The resulting compost will be primarily **worm castings** (worm manure).

To change worm bedding, either dump the contents of the bin under a bright light and brush the layers of compost away (*the worms will move away from the light and gather at the bottom of the pile*); or pull the compost plus worms to one side of the bin and add new bedding to the vacant side.

A simple alternative is to use only one-half of the box at a time; put your bedding and worms in one side of the worm bin. Continue to bury food into the bedding until it is composted. Then add new bedding to the empty half of the bin. Begin burying food on the new side.

8. Allow one month for the worms to migrate to the new side. Remove the worm castings. Repeat the process. To be certain you have all the worms from the first side, expose the worms to bright light, then wait 20 to 30 minutes. Remove the top layer until worms are exposed. Repeat until the worms are in a mass in the center of the old bedding, then add the mass of worms to new bedding. Use the soil formed by the castings on potted plants or in the garden.

Questions for the Class

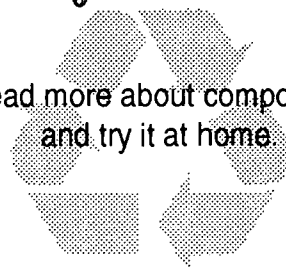
1. What are worm castings?
2. How many ounces or pounds of worms, bedding, water and food waste do you need for each cubic foot of a worm bin?

Extension Activities

1. Study the reactions of worms to different colors of light. Study the food preferences of young versus mature worms. Using four worm bins, study the reactions of the worms to the four food groups.
2. Study the other organisms present in the worm bin. What is the interrelationship of these organisms?
3. Study the effects of various mixtures of vermi-compost, peat moss, soil, and perlite on potted plants.
4. Calculate how much food the households of class members throw away in a day. Base the calculation on the fact that each South Carolina resident produces about 5.6 pounds (2.52 kg) of garbage in the home per day. (*Source: South Carolina Solid Waste Policy and Management Plan.*)
5. Discuss: Why, in a hungry world, do we throw away so much food? In South Carolina, 6.7 percent, approximately 370,000 tons, of our total solid waste stream (5 million tons) is food. (*Source: South Carolina Solid Waste Management Plan, 1995, S.C. Department of Health and Environmental Control.*)

Just Do It

Read more about composting
and try it at home.



1. Build or obtain a container.
Drill holes in 2 sides and on the bottom.

2. Shred paper for bedding.

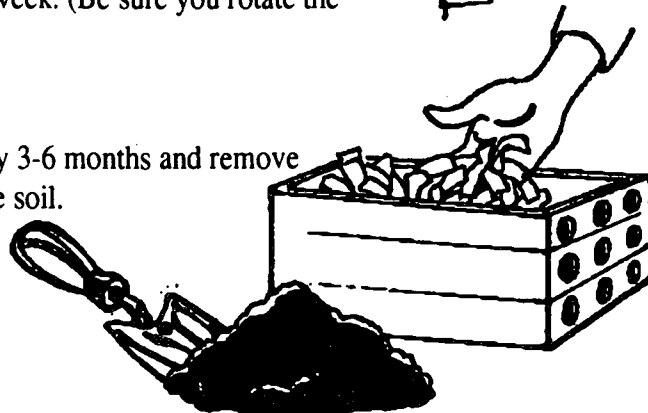
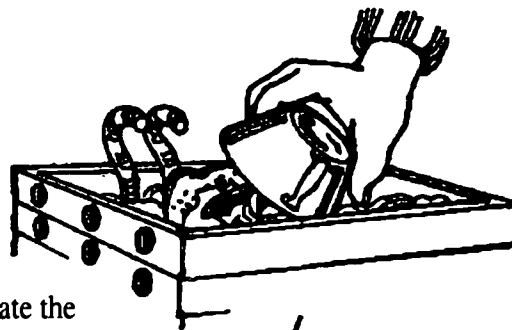
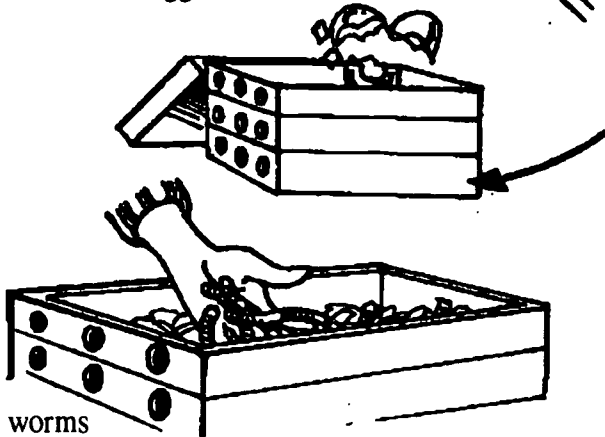
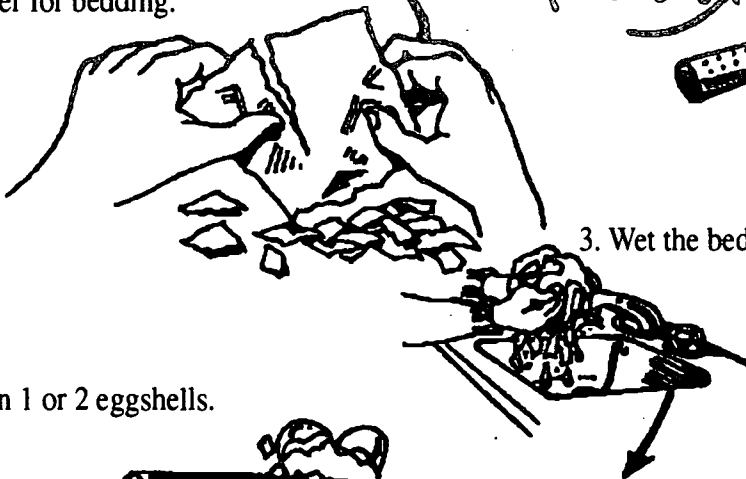
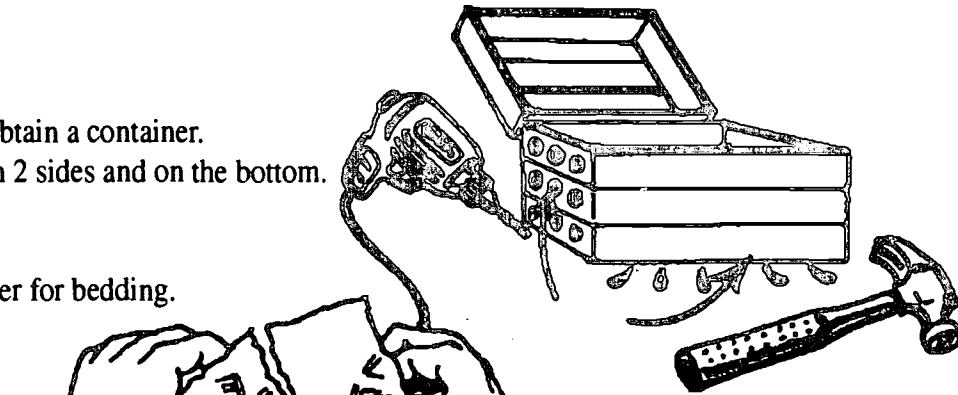
3. Wet the bedding and squeeze out excess water.

4. Sprinkle in 1 or 2 eggshells.

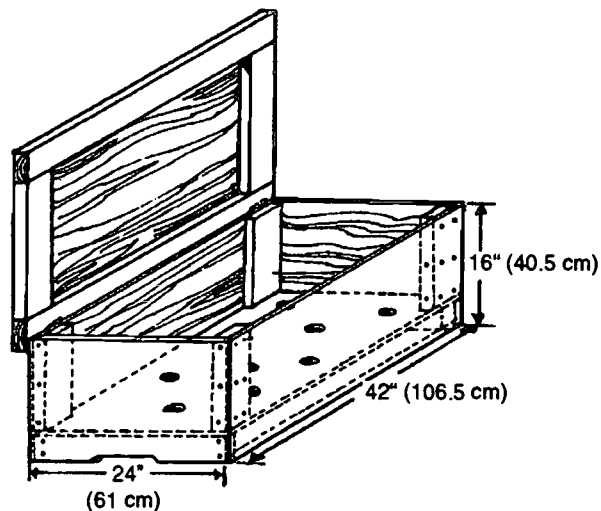
5. Place worms
in the box.

6. Bury garbage for food once a week. (Be sure you rotate the
placement of the garbage).

7. Change the bedding every 3-6 months and remove
the newly made soil.



1-2-3 Worm Composting Bin



This system is designed for composting vegetable food wastes using red worms. Food wastes and worms are “bedded” in shredded and moistened newspaper, cardboard, peat or brown leaves. The worms turn both food wastes and bedding into a high-quality compost suitable for use on house plants, seedlings or general garden use.

To maintain this system, simply rotate food wastes throughout the bin. Every 3-6 months the compost should be moved to one side of the bin and new bedding added to the empty half. At this time, start burying wastes in the new bedding only. Within one month worms will populate the new bedding, finished compost then may be harvested and the rest of the bin can be rebedded. During the winter, worm bins should be kept in a cool indoor space such as a basement or warm garage to avoid freezing. A properly maintained worm bin is odorless. Bins may be placed in a shady outdoor space the remainder of the year. Flies may be controlled by placing a sheet of plastic over the bedding.

This bin can be built for about \$35 with new wood and hardware, or less using recycled materials. Worm bins can also be made from wooden boxes or other containers. Any worm bin must have drainage in the bottom and a tight-fitting lid to keep moisture in and pests out. A starter batch of worms can be purchased at a small additional cost, or find some in an old compost pile.

Materials

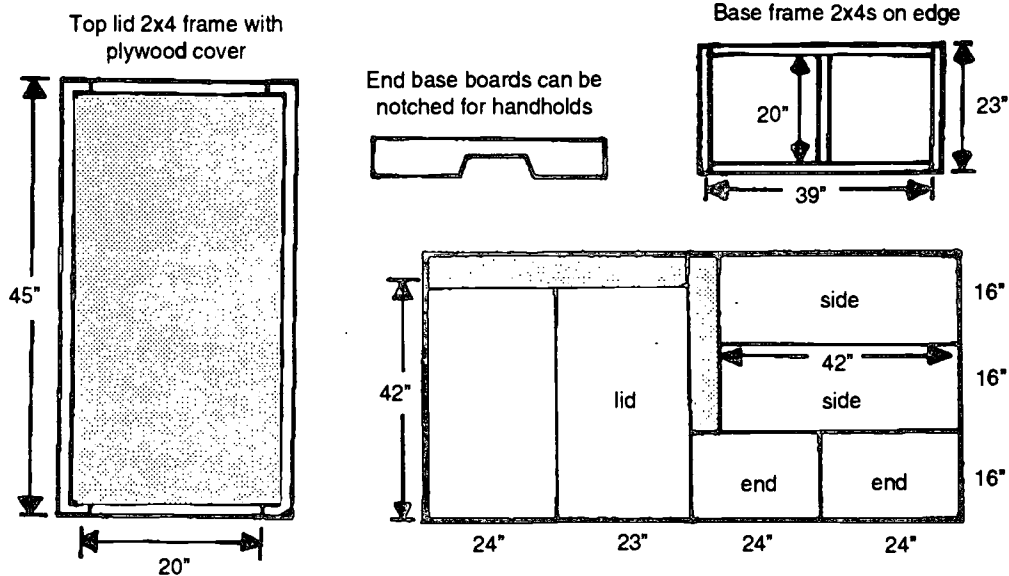
- one sheet of treated 1/2" (1.3 cm) plywood
- one 12 foot 2" x 4" (3.7 m x 10 cm)
- one 16 foot 2" x 4" (5 m x 10 cm)
- 2 lbs. (9 kg) of 6d galvanized nails
- 1/2 lb. (2 kg) of 16d galvanized nails
- 2 galvanized door hinges

Tools

Tape measure, skill saw or rip hand saw, hammer, saw horses, long straight edge or chalk snap line, screwdriver, and drill with 1/2" (1.3 cm) bit.

Use eye and ear protection.

Construction Details



Measure and cut plywood as indicated in drawing above. Cut the 12 foot 2" x 4" into five pieces: two 39", two 23", and one 20" long. Nail the 2" x 4"s together on edge with two 16d nails at each joint as illustrated in the Base Frame diagram. Nail the plywood base piece onto the 2" x 4" frame.

Cut four 1-foot lengths out of the 16 foot 2" x 4". Take each plywood side piece and place a one-foot 2" x 4" under each of its ends so that the 2" x 4" is flush with the top and side edges of the plywood, and nail the boards into place. Nail the side pieces onto the base frame. To complete the box, nail the ends onto the base and sides. To reinforce the box, be sure there is a nail staggered at least every 3 inches wherever plywood and 2" x 4"s meet. Drill twelve 1/2" holes through the bottom of the box for drainage.

To build the lid, take the remaining 12-foot 2" x 4" and cut it into two 45" pieces and two 20" pieces and lay them flat, short pieces on the inside as indicated in diagram above, so that the plywood top is inset from the edges of the 2" x 4" by 1-1/2" all the way around the perimeter. Nail the plywood onto the 2" x 4"s, and on the underside of the 2" x 4" lid frame, so that the lid will stand upright when opened.

"I'm Melting!"

6.Air.6

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6,7 & 8

Focus: Acid Rain

Subject: Science, Math, Geography

Materials: See list below.

Teaching Time: Several class periods

Vocabulary: dry fallout

Learning Objective

Students will:

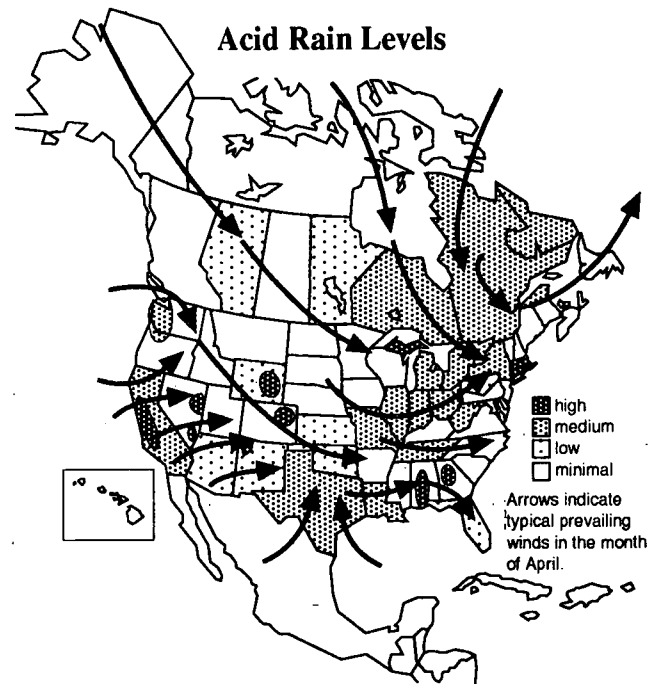
- determine how acidity and pH relate to acid rain and its effects on different materials.

Background

Acid rain is caused by the conversion of sulfur oxides and nitrogen oxides in the upper atmosphere into sulfuric and nitric acid. These acids are formed when the oxides combine with moisture in the atmosphere. They then fall to earth during precipitation in the form of rain, snow, fog and "dry fallout."

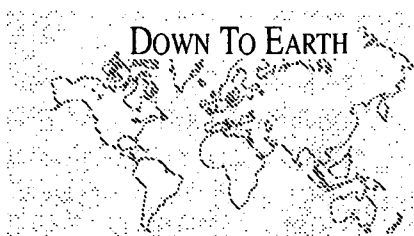
The major sources of sulfur oxides are coal-burning power plants and industrial boilers. Nitrogen oxides also come from coal-fired boilers and automobiles. In North America, the areas most sensitive to acid rain are those where acid rain falls on shallow soils and granite bedrock. Lakes that lack the ability to buffer, or neutralize, the acid are also in danger.

Acid rain has many damaging effects including killing animal life in lakes and harming vegetation. This produces a threat to people as well. In addition, many buildings and monuments made from granite and limestone are "eaten away" over time by acid rain.



This is not a new problem and there are some solutions to the acid rain problem. While this used to be a local problem in areas downwind of power plants and industrial facilities, the use of tall smokestacks sends the pollutants high into the atmosphere where weather patterns spread the pollutants over much of North America. In fact, a portion of South Carolina's air pollutants are from the Midwest and Ohio Valley regions. Coupled with the propensity for stagnant weather patterns over much of the state in the summer months, and you'll soon realize why many lazy summer days in South Carolina are hazy as well. Although this haze is from ozone in the atmosphere and has little to do with acid rain, it is a prime example of how airborne pollutants travel long distances.

The rain falling over the eastern United States and neighboring areas of Canada is 10 to 100 times



The Friends of the Boundary Waters Wilderness is a Minnesota-based environmental organization. They were instrumental in the passage of state acid rain legislation in the early 1980s. These became the strongest acid rain standards in the world.

The Information Please Environmental Almanac, 1993

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more acidic than normal. There are some storms in which the rainfall is 1,000 times more acidic. The most cost-effective, and only reliable solution to the acid rain problem, is to control the offending pollutants at their source. The goal is to emit fewer sulfur oxides and nitrogen oxides into the air so that fewer acids form in the atmosphere. Sulfur and nitrogen oxides are formed as a byproduct of combustion and are introduced into the air at high altitudes by tall smokestacks. When these oxides mix with water in the air they form acids and are introduced into the ecosystems and fall on buildings when it rains.

Plants, animals, ponds and rivers require a delicate balance of pH in order to sustain life. Acid rain can knock that pH out of balance. Buildings and statues are often made of materials such as granite, marble, limestone and copper. Acids cause these materials to deteriorate.

Acid rain varies from one rainfall to the next. In South Carolina you might record a rainfall with a pH of 6.5 one week and it might be 4.2 the next. It should be noted that rainfall is naturally slightly acidic due to the presence of carbon dioxide.

However, many factors determine the pH of rain, including the level of airborne pollutants, the type of pollutants and where they came from, how often and how much it has rained since those pollutants were introduced into the atmosphere as well as wind patterns and wind speed.

Materials

- pH paper with a color indicator chart, beakers or jars (baby food jars will work, too)
- a variety of substances such as vinegar, ammonia, tap water, rain water, groundwater, soda, lemon juice and baking soda dissolved in water (choose substances with pHs above and below 7)
- for each group, one item for each of the jars: chalk, marble chip, and pennies (because of changes in the copper content of pennies, make sure the pennies used in this lesson were minted prior to 1983).

Learning Procedure

1. Share the Background material with the class. Discuss deforestation of the Black Forest in Germany due to acid rain. Note that the South Carolina State House is being renovated. The green dome will be replaced with a new copper dome. Eventually that new dome will turn green. Why? Although the oxidation of copper (turning green) is natural, acid rain hastens this process.
2. Place each substance into a separate jar. Using the pH paper, determine the pH value for each substance. For a control, place plain water in one jar.
3. Place the jars in order of acidity or alkalinity. Note the name of the substance and the pH on each jar.
4. Place in each jar a marble chip, a piece of chalk, and a penny and note your observations.
5. Let the jars sit undisturbed for 48 hours. After 48 hours, look at the items and note any changes in their appearance. Compare the results for the different substances.
6. It may take longer for the substances to affect the penny. Let the substances sit for five days and repeat the observations.
7. The next time it rains, collect some rain water. Do not collect drips from the roof or downspout. Check the pH of the rain water. Where does it fall in comparison to your substances in your jars? Note that the pH of rain may vary widely from rainfall to rainfall.

Questions for the Class

1. Which items were the most affected?
2. What was the pH of the substance that affected the items the most?
3. How does adding acidic and alkaline compounds change water quality?

Extension Activities

1. Have students research the effects of acid rain on well-documented historical structures. Both the U.S. Capitol and the Statue of Liberty have recently undergone extensive renovations to correct damage caused, in part, by acid rain. Remember: due to the natural occurrence of CO_2 rainwater is slightly acidic anyway.

2. Perform the following experiment to test various water samples for the presence of carbon dioxide (CO_2):

Materials

200 ml beaker
2 eye droppers
phenolphthalein (Use with caution. This substance is flammable. Keep away from open flame.)
sodium carbonate (Na_2CO_3) solution
3 different samples of water labeled A, B, & C
safety glasses

Procedure

1. Pour 100 ml of Water Sample A into a beaker.

2. Add 10 drops of phenolphthalein into the water sample. Swirl GENTLY. Note: if a light pink color appears, wait one-minute. If the pink color remains, the sample has no CO_2 gas present. Record this as "zero" on a data chart.

3. If no pink color appears, measure the CO_2 present by doing the following:

a: Using an eye dropper, add sodium carbonate to the solution ONE DROP AT A TIME. Swirl GENTLY.

b: Count the number of drops of sodium carbonate needed to form a light pink color in the water sample. Note: A light pink color may form and then disappear in a few seconds. Keep adding drops of sodium carbonate only until the pink color remains.

c: Record the number of drops used in the data chart.

4. Rinse the beaker well.

5. Repeat Steps 1 through 4 with Sample B.

6. Repeat Steps 1 through 4 with Sample C.

Ask: Where does CO_2 come from in nature? How does CO_2 get into rivers, lakes, etc.? How do lakes, rivers or streams become polluted?

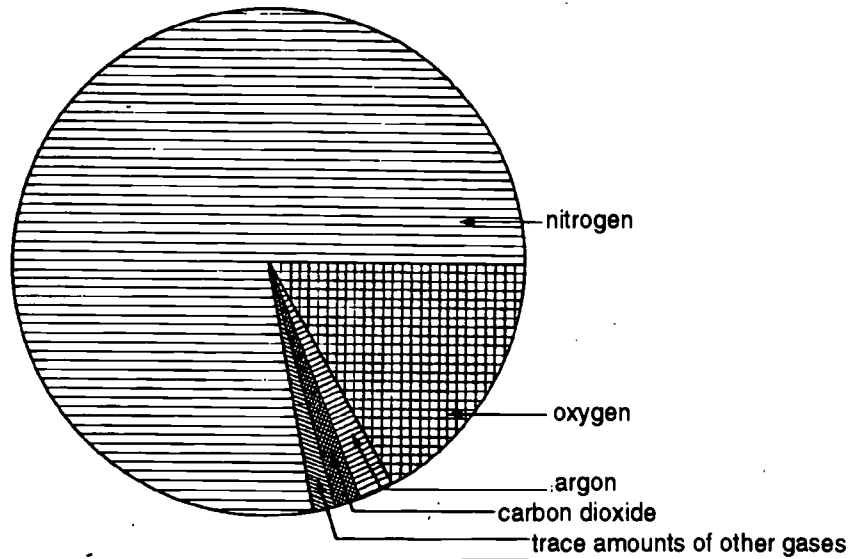
Data Collection Chart

WATER SAMPLE	NUMBER OF DROPS OF Na_2CO_3 ADDED
A	
B	
C	

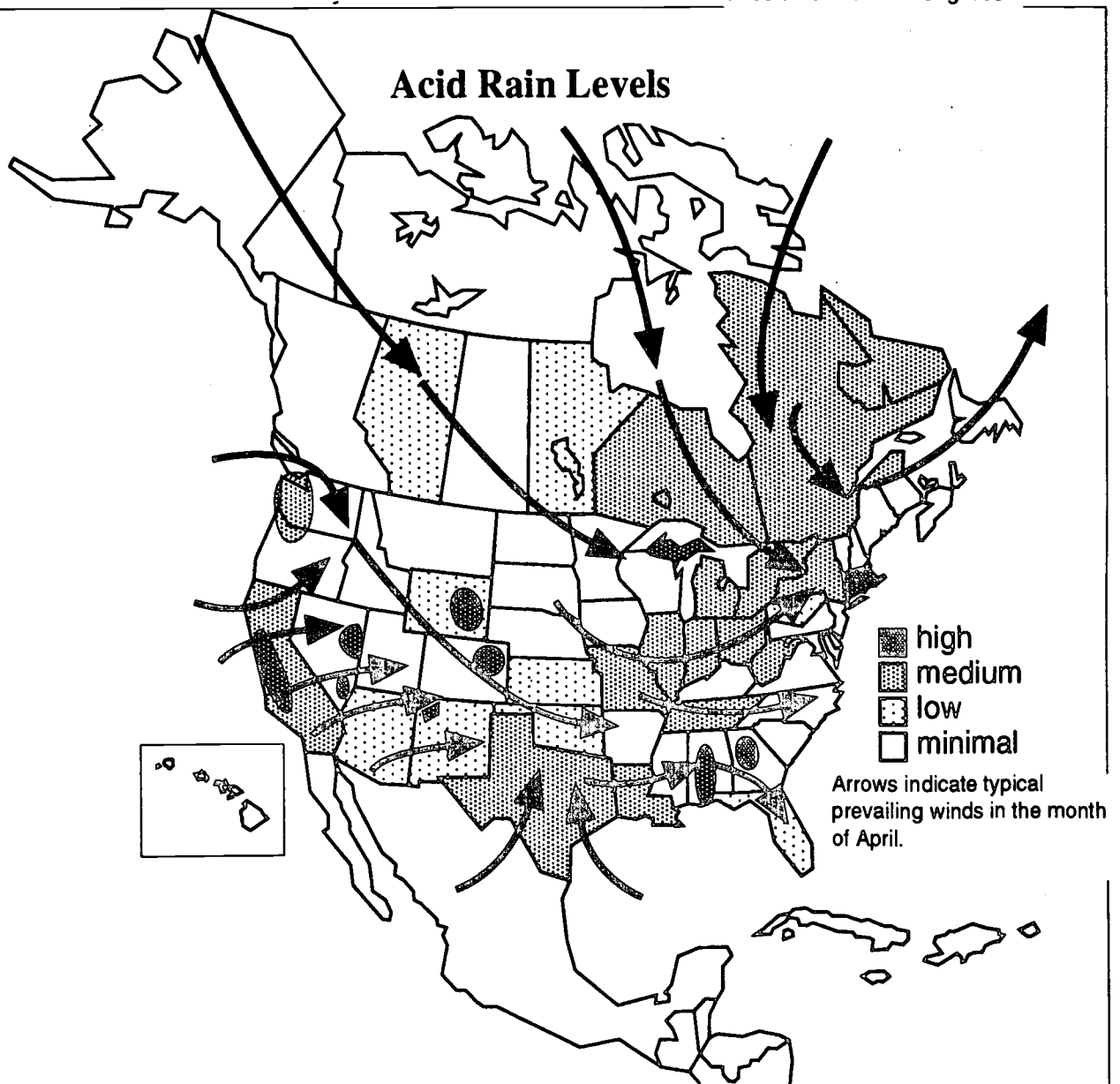
Just Do It

Note weather patterns that blow into South Carolina. Pay attention to where this "new" wind has been and then look at the economies of the states that are "up-wind" from South Carolina. What kind of pollutants do we add to this wind and send downwind? Who - or what - is downwind from South Carolina?

The Make-up of Air.



Acid Rain Levels



The Ozone or the No-Zone?

6.Air.7

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6,7 & 8

Focus: Ozone

Subject: Science, Math, Health

Materials: Clean, wide-mouthed jars with lids (mayonnaise jars work well), heavy aluminum foil, ice.
NOTE: You may wish to work in groups and will need enough materials for each group.

Teaching Time: One class period

Vocabulary: smog, ozone, CFCs

Learning Objective

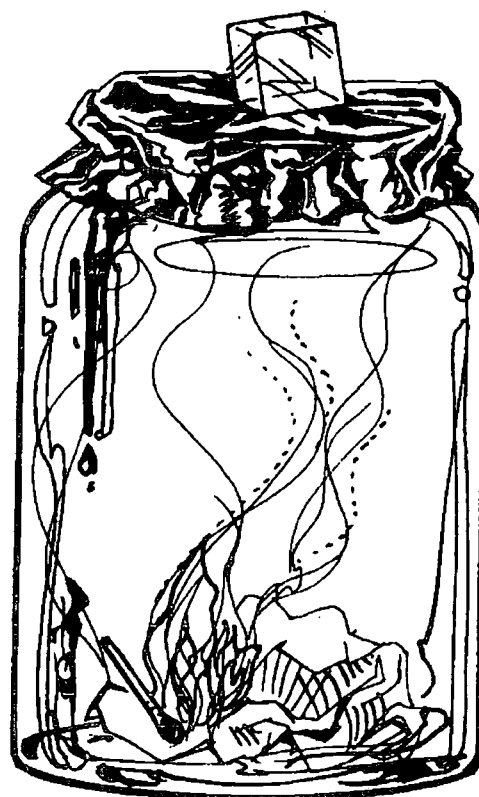
Students will:

- understand the affect rising pollution levels have on the creation of ozone and on the ozone layer
- understand the difference between ground-level and stratospheric ozone layers.

Background

Ozone is a form of oxygen consisting of three oxygen atoms linked together. Ozone is considered to be both helpful and harmful. Chemically, ozone is ozone. In other words, ground-level ozone and stratospheric ozone are the same substance. Whether or not it is helpful or harmful depends on where it is.

“Good” ozone in the upper atmosphere (the “ozone layer”) occurs naturally and protects life on earth by filtering out ultraviolet radiation from the sun. Ultraviolet radiation, among other things, produces sun tans, sun burns and, in extreme cases, can lead to skin cancer. The good ozone blocks much of the ultraviolet radiation from entering the atmosphere and reaching the surface of the Earth.



Ozone at ground level, “bad ozone,” is a noxious pollutant. It is the major component of **smog** and presents this country’s most stubborn urban air quality problem. Ozone is a severe irritant. It is responsible for the choking, coughing, and stinging eyes associated with smog. Ozone damages lung tissue, aggravates respiratory disease, and makes people more susceptible to respiratory infections. Children are especially vulnerable to ozone’s harmful effects, as are adults with existing respiratory diseases. But even otherwise healthy individuals may experience health problems from breathing ozone-polluted air.

High ozone levels also inhibit plant growth and can cause widespread damage to crops and forests.

DOWN TO EARTH

Texas releases more toxic materials into the air than any other state — about 170 million pounds. Tennessee is second.

The Information Please Environmental Almanac, 1994.

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Unhealthy ozone levels are a problem across the United States, with nearly 100 cities exceeding the U.S. EPA's National Ambient Air Quality Standard. The standard is based on the highest ozone exposure sensitive persons can tolerate. Nine cities, home to 57 million people, are considered "severely" polluted, experiencing peak ozone levels that exceed the standard by 50 percent or more. In South Carolina, all major metropolitan areas meet the federal ozone standards. However, increases in population and motor vehicle travel could lead to problems, especially if automobiles are not properly maintained and factory-installed emissions control equipment does not work properly.

Automobiles are the major source of ozone-producing pollutants. Ozone itself is not produced directly by automobiles, but is formed in the atmosphere through a series of chemical reactions involving hydrocarbons, nitrogen oxides, and sunlight. How fast and how much ozone is produced is related to both temperature and intensity of the sunlight. Because of this, high ozone levels usually occur most on hot summer afternoons. In South Carolina, the highest ozone levels generally peak in the mid- to late-afternoons, coinciding with the day's highest temperature. Generally, ozone levels are high between April and October, with May through August being the peak months.

While automobiles are the major contributors of the ozone-producing pollutants, hydrocarbons and nitrogen oxides also come from many industrial and combustion processes. However, in typical urban areas, at least half of those pollutants come from cars, buses, trucks, and off-highway mobile sources such as construction vehicles and boats.

The Clean Air Act of 1970 gives primary responsibility to state and local governments for regulating pollution from power plants, factories, and other "stationary sources." EPA has primary responsibility for regulating "mobile sources," which include cars, trucks, buses, and aircraft.

The EPA vehicle emission control program has achieved considerable success in reducing both nitrogen oxide and hydrocarbon emissions. Cars

coming off today's production lines typically emit 76 percent fewer nitrogen oxides and 80 to 90 percent fewer hydrocarbons over their lifetimes than their uncontrolled counterparts of the 1960s. The improvement is a result of strict regulations that require auto manufacturers to develop catalytic converters, systems capable of capturing excess gasoline vapors and cleaning tailpipe emissions.

Ground-level ozone in many cities has decreased with the introduction of unleaded gasoline and as newer cars with improved emission control systems continue to replace older models. Although there has been significant progress since 1970 in reducing emissions per mile traveled, the number of cars on the road — and the miles they travel — has almost doubled in the same time frame.

A second reason that ozone levels remain high is that emission control systems do not always perform as designed over the full useful life of the vehicle. Routine aging and deterioration, poor maintenance, and emission control tampering can increase vehicle emissions. In fact, a major portion of ozone-forming hydrocarbons can be attributed to a relatively small number of "super-dirty" cars whose emission control systems are not working properly.

Unless we dramatically reduce the amount of pollution vehicles actually emit, or drastically cut back on the amount we drive, smog will continue to exist in many cities.

EPA believes controlling ground-level ozone-causing pollutants such as hydrocarbon and nitrogen oxide emissions is the most promising strategy for reducing ozone levels in most urban areas. Toward that end, the federal government will establish more stringent limits on gasoline volatility, control hydrocarbon vapors that evaporate during vehicle refueling, tighten tailpipe emission standards, and require improvements in inspection and maintenance programs. EPA also is developing requirements for "warning systems" on all cars to alert drivers when the emission controls malfunction.

In the most polluted cities, however, these measures will not be sufficient. The only way to ensure healthy air is to markedly reduce our use of cars or to switch to fuels that are inherently cleaner than conventional gasoline. Using these alternative fuels means substituting methanol, ethanol, or natural gas for conventional gasoline. Using electricity would result in somewhat greater reductions in ozone-forming hydrocarbons; propane, in somewhat smaller reductions; and reformulated gasoline, in considerably smaller reductions, relative to methanol, ethanol, or natural gas fuel.

Stratospheric ozone, on the other hand, is yet another tale. The so-called “good” ozone exists 12 to 30 miles (19 to 48 kilometers) above the earth and it resides in the stratosphere. In the upper levels of the atmosphere, ozone forms a protective layer that blocks ultraviolet rays from the sun.

This protective layer of “good” ozone is being depleted by a family of chemical compounds known as chlorofluorocarbons, or CFCs. CFCs are very stable compounds that last a long time. Once they are released into the atmosphere, CFCs remain CFCs and don’t easily break down into their component elements, two of which are chlorine and fluorine. CFCs drift into the upper atmosphere — it can take decades for this to happen — where the CFCs are broken down by the sun’s ultraviolet rays, releasing the chlorine and the fluorine which then destroys the protective ozone layer.

Any ozone-depleting material released today will destroy the ozone layer many years from now. One CFC molecule can destroy 100,000 ozone molecules. It’s easy to see why ozone is disappearing much faster than nature replaces it.

CFCs, under the Clean Air Act of 1990, are being phased out of use in aerosol cans, air conditioners and refrigerators. It is currently illegal to release all refrigerants into the atmosphere. Other ozone-depleting substances include solvent cleaning products, refrigeration and air conditioning fluids, foam products such as polystyrene, aerosols, and other products such as halon which is used in some fire-suppressant systems.

Learning Procedure

1. Explain that the class will be making artificial smog in a jar. Remind them that this is only a demonstration, and they will only be replicating the *appearance* of smog, not the actual make-up of smog or its effects. Remind them that smog is *not* smoky fog.
2. Cut a strip of paper about 6 inches x 2 inches. Fold it in half and twist it into a rope-like shape.
3. On the top of the jar, form a snug lid for the jar using aluminum foil. Make a small indentation to keep the ice cubes from sliding off. Carefully remove the foil lid and set it aside.
4. Put a little water in the jar and swirl it around to wet the inside of the jar. Pour off any excess water.
5. Light the paper and drop it and the match into the jar. Quickly put the foil lid in the jar and seal it tightly. Place the ice on the lid to make it cold so that the water vapor in the jar will condense. This step must be done very quickly so the students may need some help.
6. Have the students record their observations. Does this look like real smog? What is the “smog” in the jar made of? (water vapor, soot particles, carbon dioxide and other vapors)

Questions for the Class

1. Ask students to identify trips they themselves make in cars that might be unnecessary, trips that could be eliminated, or those which could be accomplished by other means of transportation.
2. How does urban growth affect air pollution? Housing patterns? Where people live in relation to where they work, shop, go to school?
3. What are the advantages and disadvantages of mass transit? Carpooling? Taking the school bus?
4. How many cars are registered in your city? County? South Carolina? The South Carolina Department of Transportation can provide this

information and may be a good source for a classroom speaker.

5. What is a catalytic converter? How does it change auto emissions? A professional mechanic could bring a catalytic converter to class and discuss its operation.

6. South Carolina recently changed the law requiring annual safety inspections for cars. Some states still require safety inspections as well as annual emission inspections. Although we do not require emission inspections in this state and since we no longer require safety inspections, will this affect air quality in South Carolina? In the United States?

7. What are some of the alternatives to automobile transportation? (*Mass transit, bicycles, etc.*)

Extension Activity

Some fuels are inherently cleaner than gasoline because they emit fewer nitrogen oxides or hydrocarbons, and because the hydrocarbons they do emit are less likely to react in the atmosphere to form ozone. Have students research and write a report on one or more of the following alternative fuels:

- **ALCOHOLS:** Methanol (made from natural gas, coal, or biomass) and ethanol (made from grains or sugar) are high-octane liquid fuels. Cars designed to run on pure alcohol fuels have the potential to emit 80 to 90 percent fewer reactive hydrocarbons than advanced-technology gasoline cars.

- **ELECTRICITY:** Battery-powered cars have the potential for zero tailpipe and evaporative hydrocarbon and nitrogen oxide emissions, although we must still account for power plant emissions. Today's electric vehicle technology is limited, but promising recent developments may lead to more widespread use in the future.

- **NATURAL GAS:** Compressed natural gas is also an excellent automotive fuel, particularly for fleet vehicles where long driving range is not important. Natural gas vehicles have the potential to emit 85 to

95 percent fewer reactive hydrocarbons than advanced-technology gasoline vehicles.

- **LIQUID PETROLEUM GAS (PROPANE):** Propane is a byproduct of petroleum refining and natural gas production. Propane vehicles emit considerably less ozone-forming hydrocarbons than do vehicles fueled with conventional gasoline.

- **REFORMULATED GASOLINE:** The petroleum industry is studying ways to change refinery procedures to make a cleaner-burning gasoline. A number of "clean" gasolines have recently been introduced into the marketplace, and research is continuing to develop even cleaner fuels. Reformulated gasolines are capable of reducing hydrocarbon emissions by at least 15 percent.

Just Do It

To fight ozone loss:

- 1) Service and dispose of your home air conditioner or refrigerator responsibly
- 2) Repair or maintain your car's air conditioner.
- 3) Avoid using halon fire extinguishers.
- 4) Choose insulation made from cellulose or fiberglass, not products containing CFCs.
- 5) Avoid products with methyl chloroform, also known as 1,1,1-trichloroethane which can be found in such common products as fabric protectors, spot removers, and bug sprays.

Feelin' Alright?

6.Air.8

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6,7 & 8

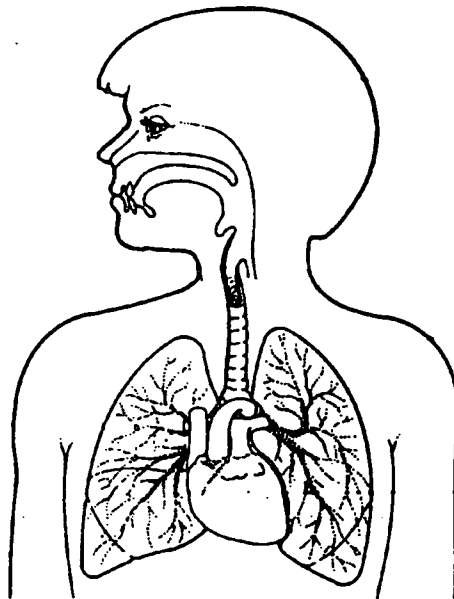
Focus: Health effects of air pollution

Subject: Science, Health, Geography

Materials: Transparency, environmental health care professional (optional)

Teaching Time: One class period, out of class research

Vocabulary: particulates



Learning Objective

Students will:

- gain knowledge of how pollutants affect our health.

Background

Different pollutants affect our health in very specific ways. In fact, physical symptoms are often a good clue to identifying which pollutants are out there bothering people.

Prolonged exposure to these compounds can affect people in predictable ways. According to the U.S. EPA, carbon monoxide causes headaches, blurred vision and slow reflexes. Lead causes learning difficulties and alters kidney function and blood chemistry. Sulfur dioxide will cause heart and lung problems and can also harm vegetation and metals. Particulates, dust, soot, etc., can irritate the throat and cause heart and lung problems as well.

Nitrogen dioxide may cause increased respiratory illness such as chest colds and coughing, and may cause increased breathing difficulties in asthmatics. Ozone causes choking and coughing as well as irritates the eyes throat and nose.

Learning Procedure

1. Share the background material and use the transparency (included) to discuss the health effects of these pollutants.
2. Assign to the students the different pollutants and have them research their sources, which areas of the country/world have the highest concentrations, do areas without any immediate sources of these pollutants have anything to worry about?

Questions for the Class

1. Are some of these air pollutants found indoors? Outdoors?
2. How would weather affect the concentration of air pollution?
3. Which items that we deal with everyday would you be willing to live without if it would eliminate air pollution? Cars? Manufactured items? Household products?

DOWN TO EARTH

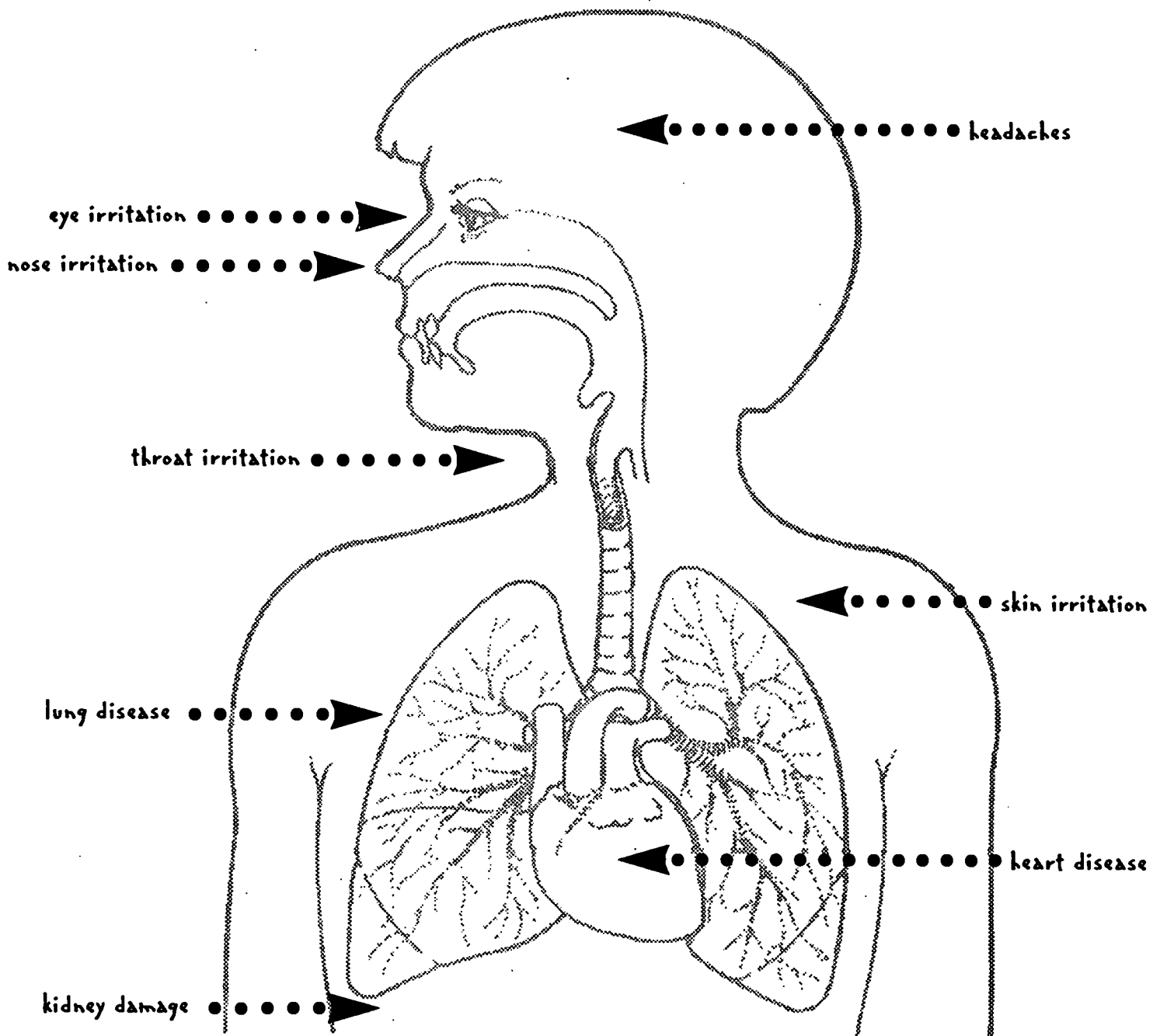


The number of vehicles in use around the world is unexpected to double to around 1 billion within the next 40 years. Much of this growth will take place in developing countries where the automobile population is expected to increase by more than 20 percent by the end of the century.

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AIR POLLUTION & YOU



AIRBORNE PARTICULATES

- irritates your throat
- causes heart & lung problems

OZONE

- irritates your eyes, nose and throat
- causes choking and coughing

SULFUR DIOXIDE

- causes heart & lung problems
- harms vegetation and metals

CARBON MONOXIDE

- causes headaches
- causes slow reflexes
- causes blurred vision

NITROGEN DIOXIDE

- increases respiratory illness such as colds
- increases breathing difficulties in asthmatics

LEAD

- causes learning problems
- alters kidney function
- alters blood chemistry

Living in the Greenhouse

6.Air.11

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6,7 & 8

Focus: Greenhouse effect

Subject: Science, Math, Health

Materials: Clean, wide-mouthed jars with lids (mayonnaise jars work well), dark cloth or construction paper, watch with a second hand or a stop watch, meat thermometers that will fit into the jars. NOTE: You may wish to work in groups and will need enough materials for each group.

Teaching Time: Two class periods, outside

Vocabulary: greenhouse effect, electromagnetic energy, incident light wave

Learning Objective

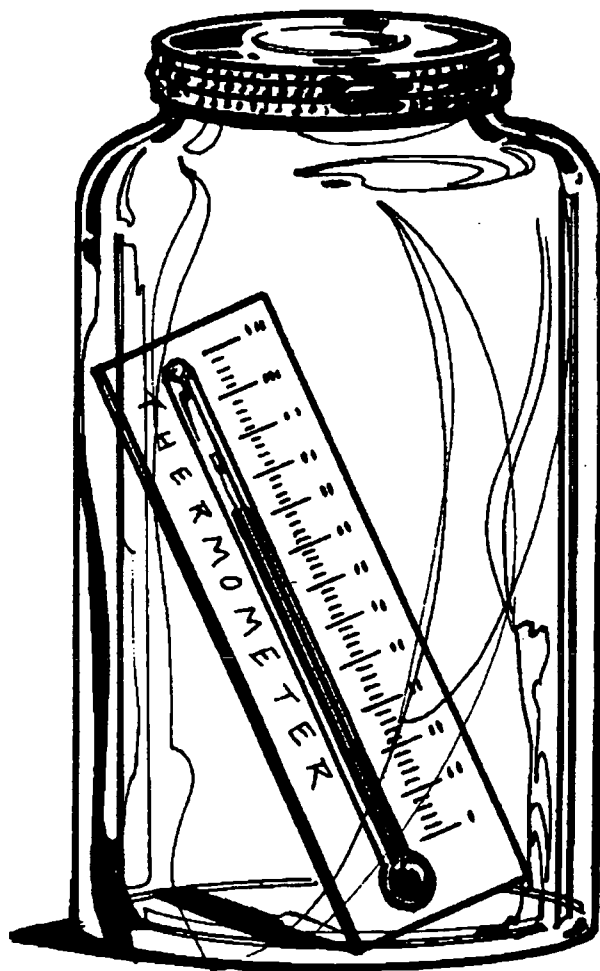
Students will:

- understand that our atmosphere traps heat
- understand that pollutants in the air can increase temperatures that may harm the environment
- understand how human activities can cause air pollution.

Background

The **greenhouse effect** is a term that describes the trapping of heat on the surface of the Earth by the atmosphere. This is a normal event and is one of the things our atmosphere is designed to do. Without our atmosphere trapping heat, average temperatures worldwide would be about 53 degrees Fahrenheit (12 degrees Celsius) cooler, according to the U.S. EPA.

Certain air pollutants, however, magnify the atmospheric heat trapping. These gases are carbon dioxide, nitrogen oxides, methane, and CFCs or chlorofluorocarbons. CFCs are chemicals often used in air conditioners, refrigerators, and aerosol cans.



The use of CFCs are being phased out and replaced with chemicals thought to be less harmful to the atmosphere than CFCs. Methane is a byproduct of the natural decay of living, or once-living, things. Nitrous oxides are the result of man-made burning and internal combustion engines such as automobiles, trucks, and buses. While there are many contributors to the greenhouse effect, many scientists believe that carbon dioxide is the most significant greenhouse gas.

DOWN TO EARTH



A warmer global climate can greatly effect polar regions. For example, in the northern polar regions, higher temperatures can result in thinner ice. as well as cause the permafrost to gradually that. this would release large amounts of methane trapped in the ice and amplify greenhouse warming.

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Some reports show that the concentrations of greenhouse gases in our atmosphere will double over the next 100 years. This could increase our temperatures eight to 10 degrees Fahrenheit (4 to 6 degrees Celsius). There are other theories that say that increased levels of greenhouse gases in the atmosphere will increase cloud cover which will reflect sunlight away from the Earth, resulting in an overall decrease in the Earth's temperature.

Light, or **electromagnetic energy**, that reaches Earth is radiated from the sun and passes through the atmosphere to the surface where it is absorbed. Some incoming, or **incident light waves**, are reflected away by clouds or light-colored surfaces such as the polar ice caps or large snow fields.

The energy that is absorbed by the surface of the Earth is converted into heat energy that is re-radiated back into our atmosphere. This heat energy is not visible to our eyes, but can be seen in the infrared range of the light spectrum. Water vapor and carbon dioxide as well as other components of the atmosphere, especially the greenhouse gases, can not be seen by our eyes but they do react to this re-radiated heat energy, trapping the heat within our atmosphere and generally warming the surface temperature of the Earth. This is the greenhouse effect.

Deforestation contributes to the greenhouse effect by removing plant life from the oxygen production cycle. Humans produce carbon dioxide, both through burning as we have seen, and through breathing. Plants "breathe in" carbon dioxide and produce oxygen. With fewer plants available as a result of massive deforestation, carbon dioxide levels will increase.

As the population continues to escalate on the planet, more and more carbon dioxide and methane are released into the atmosphere. All of us need to be aware that our actions do contribute to the production of greenhouse gases.

Learning Procedure

1. Give each group a set of materials (jar with lid, dark cloth or paper, thermometer). Prepare the jars by placing the dark cloth inside the jar on the side. Place the thermometer on the cloth. Outside, place the jar on its side with the bottom facing the sun and the thermometer positioned so students can read it without removing it from the jar.
2. With the jar lid on, record the temperature each minute until it reaches 140 degrees Fahrenheit (60 degrees Celsius). Note the beginning temperature and how long it takes to reach 140 degrees Fahrenheit (60 degrees Celsius). Also note the ambient, or outside temperature. Is it a cloudy day or a bright sunny day?
3. Allow the jars to cool and repeat step 2, this time without the lids on the jars.

Questions for the class

1. Which jar has the fastest temperature rise? How much faster? Why?
2. How is this like a greenhouse?
3. How is this like the Earth's atmosphere?
4. What was the purpose of the dark cloth in the jar? What, on Earth, does the dark cloth represent?

Extension Activities

1. Visit a greenhouse and have the gardener talk about why it is helpful to the plants. Have the gardener discuss what could happen to the plants if it got too hot in the greenhouse. Discuss with the class how increased temperatures in the greenhouse might relate to increased temperatures in the atmosphere.
2. Repeat the experiment, this time covering the jars with aluminum foil, leaving a small window, away from the sun, to read the thermometer. Does it take longer to reach 140 degrees Fahrenheit? Why?

Erosion: Rubbing the Earth the Wrong Way

6.nps.1

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 - 8

Focus: How water volume and velocity affect the erosion of soil.

Subject: Science

Materials: Sand or sandy soil, clay soil, eye dropper, 4oz. cup, 16oz. cup, water, ladder (or way to pour water from 6 feet high)

Teaching Time: Several class periods, this activity should be done outside.

Vocabulary: Erosion, sediment, pollution, turbidity, suspended solids, clarity, photosynthesis, secchi disk



Learning Objectives

In this activity, students will:

- see how erosion can cause pollution that alters the environment
- identify ways to reduce erosion.

Background

Sediment – soil particles, sands, and minerals – from land **erosion** are washed from the land through natural runoff, agricultural development, mining, and construction activities. At a billion tons a year, sediments produce the most **pollution** by tonnage worldwide. This is 700 times greater than the solids from sewage discharges.

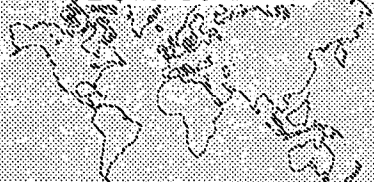
Natural erosion rates of land, which are already high in many areas, may be increased 4 to 8 times by agricultural development, 10 to 50 times by careless construction. Enough topsoil erodes away each year to fill 18 freight trains, each long enough to reach around the entire world.

Sediment fills stream channels, harbors, and reservoirs, reduces fish and shellfish populations, erodes hydroelectric equipment, and reduces the amount of light that reaches aquatic plants.

Turbidity is the term for **suspended solids** that decrease the ability of sunlight to penetrate the water. Common causes of turbidity include plankton and soil particles. Many streams are being affected by increased turbidity due to construction, logging, mining, and improper agricultural practices. In clear water, light travels in a straight line; the particles in turbid water cause light to scatter.

For fish and aquatic animals, changes in turbidity can drastically alter the environment. Fish may be largely unaffected by slight reductions in clarity because of floating algae. However, an equal reduction in **clarity** caused by soil particles could affect fish health by irritating the gills.

DOWN TO EARTH



In Africa, Mozambique's mangrove forests – which comprised 48 percent of the coastline, have been reduced 70 percent over the last 20 years. Loss of these forests makes coastlines more vulnerable to erosion, adversely affecting marine populations.

source: 1994 *Environmental Almanac*

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Aquatic fauna (animal life) are adversely affected by turbidity that directly causes suffocation or abrasion; impairs successful reproduction and development of eggs and larvae; weakens their survival rate by making them more susceptible to disease; lowers the abundance of available food; or changes natural habitats and movements.

When turbidity increases (more siltation in water), plant growth is reduced. When the photic zone — the zone illuminated by sunlight — is decreased, **photosynthesis** by plants will also decrease and limit the available food supply.

Newly constructed ponds are often treated for turbidity (muddy waters) by adding gypsum. Frequent or enduring muddiness requires a long term solution such as stream bank stabilization, or vegetative cover, plus controlling the quality of the runoff into the pond.

A **secchi disk** is a large disk used to test for turbidity. The disk can be made of fiberglass, wood, metal, etc. It should be 20 cm in diameter and divided into four sections with each section alternating black with white. A hole is left in the middle of the disk so that a rope may pass through the disk. A weight is added to the underside of the disk to make it sink in the water. The disk is lowered into the water until it disappears from sight and is then raised slowly until it is just visible again. The distance halfway between the points of disappearance and reappearance of the disk is taken as the secchi depth. The secchi depth of muddy streams will fall between 0 and 2 meters but may be as great as 40 meters in a very clear lake.

Learning Procedures

1. This activity takes place in two sessions. The first activity is to build two mounds of soil – each 2 feet high – one from sandy soil, one from clay soil.
2. Drop 10 drops of water from an eyedropper from 2 feet onto both mounds of soil. Have students observe any marks made by the water.

3. Repeat process from 6 feet. Have students observe any marks made by the water.

4. Pour 4 oz. of water onto each mound from one foot above. Have students observe any marks made by the water.

5. Pour 4 oz. of water onto each mound from from 6 feet. Have students observe any marks made by the water.

6. Pour 16 oz. of water onto each mound of soil from one foot. Have students observe any marks made by the water.

7. Pour 16 oz. of water onto each mound of soil from six feet. Have students observe any marks made by the water.

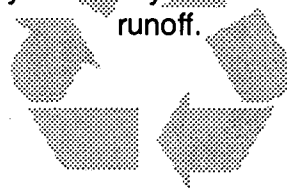
8. The second portion of this activity is to find places close to school where this type of erosion has occurred. **Note:** Notice the little ditches under roofs, erosion at the end of cement in drainage ditches, and the sides of a parking lot.

Questions for the Class

1. Have the class list three examples of this type of erosion. Discuss how, with some forethought, this problem can be helped.

Just Do It

Look for erosion and sources of runoff around your home. Consider planting greenways around your home to reduce runoff.



Extension Activities

1. Have students make their own secchi disk and test various water sources for clarity.

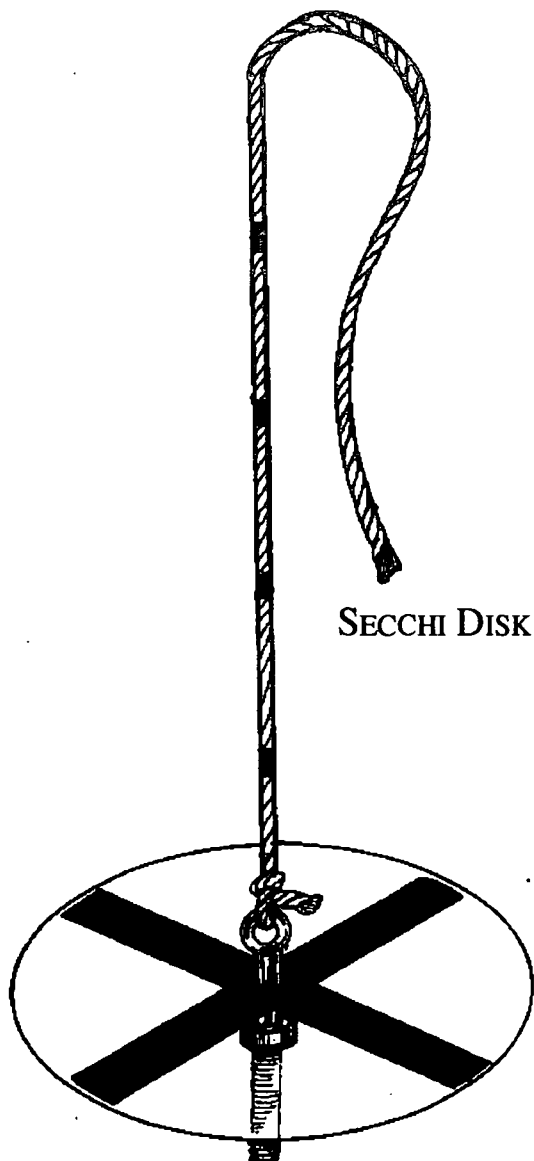
Discuss with the class how turbidity from siltation effects streams. What do plants need for growth? — one answer should be light. Do underwater plants need light too? — yes. What happens if those plants can't get enough light? — they die, which means less food and cover for many animals, etc. Young and otherwise vulnerable creatures find protection in beds of underwater plants. These plants feed and protect many types of the marine life that we eat. Can you name some? — fish, crabs and other seafoods: many people also eat ducks and geese, etc.

Have the students brainstorm sources of sediment. Try to use specific examples that they have seen in the area or at home.

This activity uses a secchi disk to measure depth of light penetration or turbidity. The deeper the disk is visible, the less turbid the water. Secchi disks should be used in water that is fairly deep and slow or still.

Materials:

- Sources of clear and muddy waters (outside or created inside in aquariums or coolers)
- Black and white waterproof paint (spray paint works well, only white paint is needed with old record albums)
- 20 cm diameter disk made of wood or old record albums or paint can lids at least 6 - 8" in diameter
- Drill or ice pick (to make center hole, do not need if you use old record albums)
- Lead weights (fishing weights work well)
- Rope/ heavy string
- Tape measure
- Large eye bolt and nut
- Paper
- Black permanent markers
- Lamination (if available, this allows students to try out a paper secchi disk)
- Old record albums that do not have to be returned



Have students make a paper model of a secchi disk, according to the description in the background. If available, laminate these disks to use in experiments. Or, have students construct a secchi disk as a group from wood, old records or paint can lids. (Use heavy, solid wood, some will float even if weighted.)

To make a secchi disk from a paint can lid:

- Paint the can lid white, then paint a large black X on top.
- Punch or drill a small hole in the middle of the X and attach a string to the lid using an eye bolt and nut, or tie it and use weights.
- Mark off 0.1 meter increments on the string with a waterproof marker.

At a pond or lake: gently lower the disk into water until you can no longer see the X. Inch the disc back up until you can just barely see the X; hold the disc there. Reach down and grasp the string height at the surface of the water, and hold the string there while you pull the disk back out. By reading the markings on the string, determine the depth to which the light could penetrate. Compare readings from several places in the water. It is recommended that secchi disk readings be made between 9 am and 3 pm from the shady side of a dock, boat, etc.



Were there places that were more turbid than others? Were you able to see what caused the turbidity? Hint: Look for places where runoff and sediment are washing into the water from land. Are there fish or people stirring up the water?

2. Have students find a stream, pond or lake where high turbidity has been observed and determine the cause. Caution students not to go near water without supervision.

3. Have students write a paper from the perspective of a fish in muddy water and in clear water. They should address such questions as what they would eat in each environment, how reproduction, feeding, and migration will be affected, and their preferred habitat.

Runaway Water

6.nps.2

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 - 8

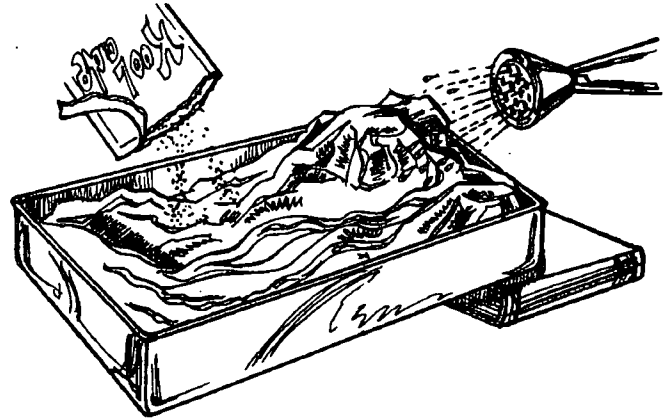
Focus: Understanding South Carolina's watersheds and how runoff can affect water quality.

Subject: Science, Geography

Materials: See itemized list below

Teaching Time: Several class periods

Vocabulary: Watersheds, runoff, storm drains, pollution, groundwater, nonpoint source pollution



Materials for making a watershed:

- shallow baking pans
- small cups or block
- aluminum foil
- dark colored powdered drink mix (red works well)
- watering can
- water

Materials for reviewing South Carolina watersheds:

- a large S.C. map showing bodies of water
- water basins map included with this lesson
- maps from SC Maps Program of local area. You may use aerial maps of the school and adjacent areas or a wider view of your area.

Learning Objectives

In this activity, students will:

- see how South Carolina's watersheds direct the flow of runoff water
- see how man-made building, construction, and land clearing affect the path of water and water quality
- identify sources of pollution close to home and ways to prevent it.

Materials

This lesson includes an activity to make a simple watershed model and a review of South Carolina water basins. A map is included with this lesson. Extension activities suggest use of infrared maps and other maps available through the South Carolina Maps program that can offer an aerial view of your local area. If you plan to use these maps and your school does not have them, please allow time to obtain the maps.

Background

Exactly where water travels and how quickly it moves depend on various factors, such as an area's topography and vegetation, and its soil and rock types. Precipitation falls into water or on land, where it "runs off" of a hard surface such as rock or concrete or infiltrates a soft surface such as soil or sand. If water moves downward, it can replenish water contained in the underground rock and

DOWN TO EARTH



In Haiti, although groundwater is plentiful, safe drinking water is scarce. Sewage systems and sewage treatment are nonexistent. Waterborne diseases are widespread.

source: 1994 *Environmental Almanac*

sediment. This supply of water is referred to as **"groundwater."** Water remaining on the surface may flow through wetlands and enters local streams, rivers and lakes.

This land area from which water drains to any given point is referred to as a **"watershed."** For instance, a lake's watershed includes the streams entering it and the hills that drain into these streams and eventually into the lake. A large river, fed by many streams, is made up of many watersheds and is referred to as a **"drainage basin."** South Carolina has four major drainage basins, which themselves comprise many miles of rivers and streams, acres of lakes and square miles of wetlands and estuaries. (See map.)

Nonpoint source pollution, or NPS, is **runoff** water pollution that originates from many sources rather than one known point, such as an industrial discharge pipe or a tanker oil spill. This runoff **pollution** is any man-made or natural material carried by rainwater over land to enter **storm drains**, ditches, streams, rivers, estuaries, lakes, groundwater, and even the ocean itself, and thus becomes a part of the water cycle. This pollution may also come from man-made or natural materials dumped or emptied into the soil.

Examples of nonpoint source or runoff pollution include soil eroded from construction sites; fertilizers and pesticides from fields and lawns; metals and oil from automobiles; road salts; improperly discarded household hazardous waste; malfunctioning septic systems; animal waste from horses, cattle, waterfowl and pets; and excessive amounts of grass clippings, leaves and other natural debris. Man-made or natural materials, in small amounts, may not pose a threat to the environment. However, in amounts large enough to harm the organisms living in or using the water in a given area, these materials are pollution and degrade the quality of water. Excessive runoff pollution may also restrict many important uses of water such as drinking water, fishing, swimming, shell fish harvesting, etc.

The problems associated with nonpoint source

pollution statewide appear to be proportional to the state's population density and distribution, and the intensity of agricultural activity and other land uses.

South Carolina's growing population of more than 3.6 million people is not equally distributed. Most people live near Columbia, Charleston, and the Greenville/Spartanburg area. In these active, urban regions, nonpoint source pollution amounts are prominent, though signs of it are found statewide. The growth of light industry, suburban expansion, and improved transportation corridors have exposed agricultural areas and vacant lands to development.

South Carolina's more rural counties, also suffer with various nonpoint source pollution symptoms, especially from farming activities.

Waterfront properties continue to attract both homeowners and businesses alike, developing or redeveloping properties along lakes, rivers, estuaries and oceanfront. Although these people do not pollute water deliberately, their actions and activities contribute to nonpoint source pollution.

The types and amounts of nonpoint source water pollution in any given area vary throughout the state. While rural areas have concerns with fertilizers, pesticides, sediments and animal waste; urban areas suffer more from trash and litter, chemicals and metals collected from paved areas by stormwater runoff; and coastal areas are damaged by construction and over-used or poorly maintained septic systems. The topography of the land, water velocity and depth, amount of rainfall and vegetation, weather conditions and the soil and rock types influence how quickly the pollutants mix with water and proceed to travel.

Nonpoint source water pollution has been identified as affecting water quality to some extent in all watersheds in the state. Under the federal Clean Water Act, state officials assessed South Carolina's nonpoint source water pollution and identified more than 336 waterbodies as pollution problem areas.

Learning Procedures

1. Discuss the background information with the class and help them define “watershed” and “nonpoint source water pollution.” Use a large South Carolina map to pinpoint your county in the state, nearby waterways, and major waterways. Use the map included with this lesson to identify your drainage basin.

Discuss how water in your area is connected to a variety of land uses and human activities on land. Is your local area rural, suburban, or urban? What do local waterways flow through and how are they affected along the way?

As a class have students participate in creating a map that characterizes your area and the things that may affect your waterways. What you find depends upon your area. Some things to look for are:

Rural

- Horse farm/ horses
- Agricultural farm/ crops
- Irrigation ditches
- Septic systems
- A home
- Schools

Suburban

- Housing development
- Condominiums
- Apartment complex
- Shopping mall/ parking lot
- Schools
- Construction site
- Stormwater system
- Roadways
- Pets
- Small marinas
- Golf Courses
- Gas stations

Urban

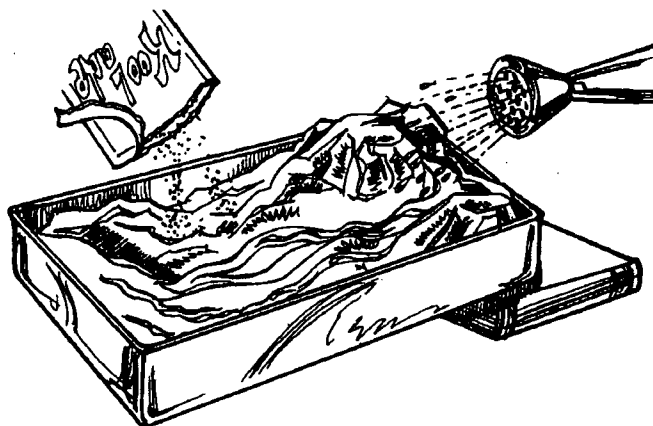
- Many large buildings
- Industrial sites
- Wastewater facility
- Construction site
- Stormwater system

Many roadways

Pets

Large shipyard

2. In groups or as a demonstration, create the simple watershed model. (See illustration.)



Ask the class: What makes rainfall from the sky? (*gravity*) Does this also make water run downhill? (*yes*) Most waterways and wetlands lie downhill of the land around them. Rainwater runs downhill and eventually reaches these waterways.

Make a watershed: Place small cups or blocks in one end of a shallow baking pan; prop this end up on a book. Tear off a piece of aluminum foil longer than the size of the pan. Crinkle the foil. Cover the blocks or cups with the foil, and make a basin in the foil at the other end. This represents a watershed. The high end represents mountains or hills, the creases in the foil are streams and rivers that are bordered by wetlands, the basin is a large body of water (a lake or bay) that the rivers eventually flow into.

Pour “rain” gently over the watershed using cups or watering cans. Where does it all run? What would happen if the land had pollutants on it? Sprinkle some drink mix “pollutants” onto the watershed. Make it rain again and watch what happens.

What kinds of pollutants does the drink mix represent? It could be soil, fertilizer, chemicals, trash, gasoline or oil, etc. How do these pollutants get on the land and in

the water? Are you responsible for any of these actions?

What can you or other responsible people do to help prevent this pollution?

3. Use the "Getting to the Source" student worksheet included with this lesson to review the sources of nonpoint source water pollution.

Extension Activities

1. Have students clip ads and newspaper and magazine articles from both local and national sources that can be directly or indirectly related to nonpoint source pollution.

2. Use maps from the South Carolina Maps program to take an aerial look at your local area. Trace local waterways and consider the factors that might contribute to nonpoint source pollution as rainwater moves across the land and flows through waterways.

Have students create a map/drawing of their local area including buildings, roadways, and waterways. You may start at the school and the closest body of water. Students may use the sample map key symbols to mark on their maps for areas of interest.

Sample Map Key



Houses



School



Stores



Industry



Construction



Wetland (vegetated)



Wetland (disturbed)



Dump Site



Landfill



Parking lot



Marina

Waterway



Highway



Paved Street



Dirt or gravel road



Farms

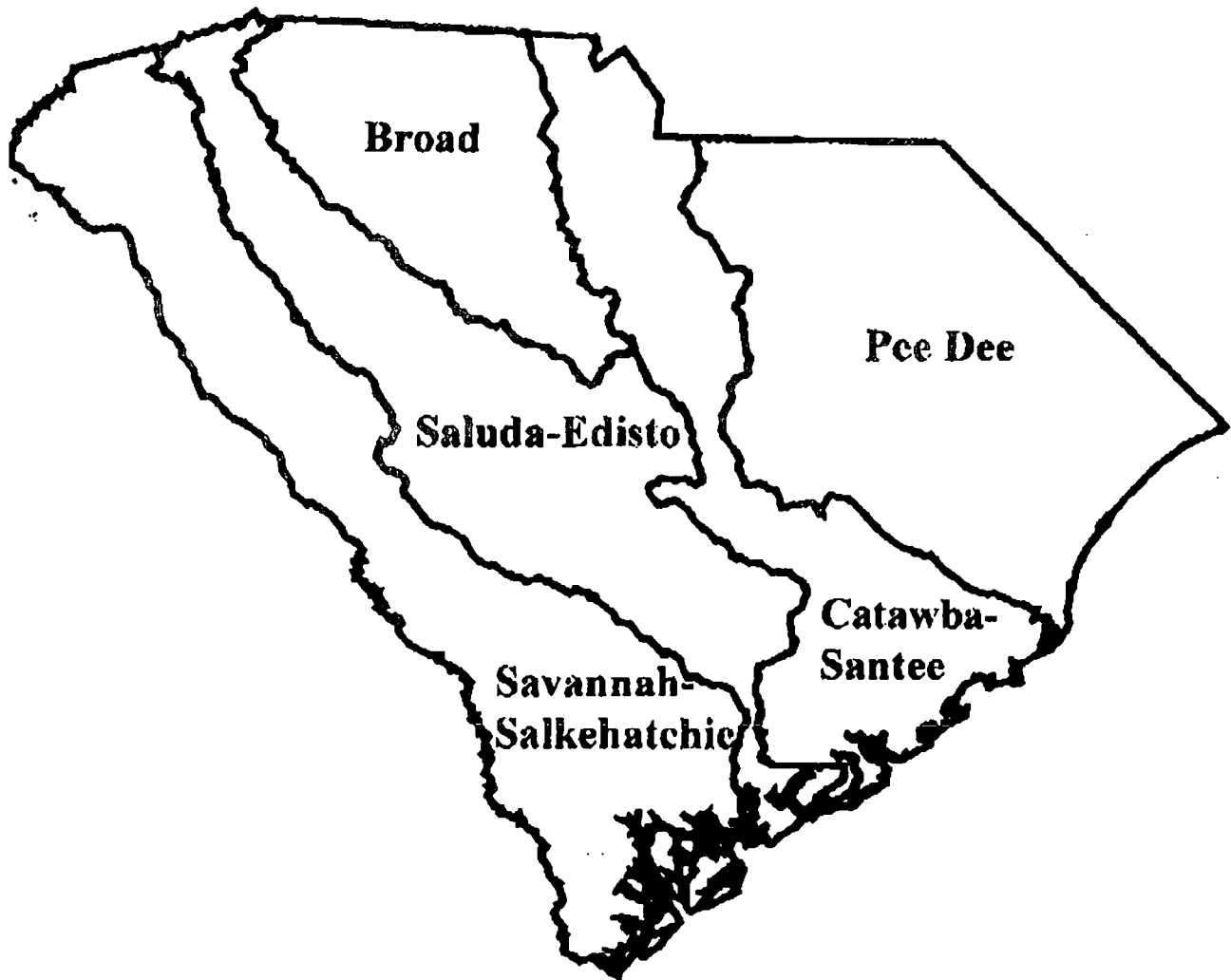


Forest

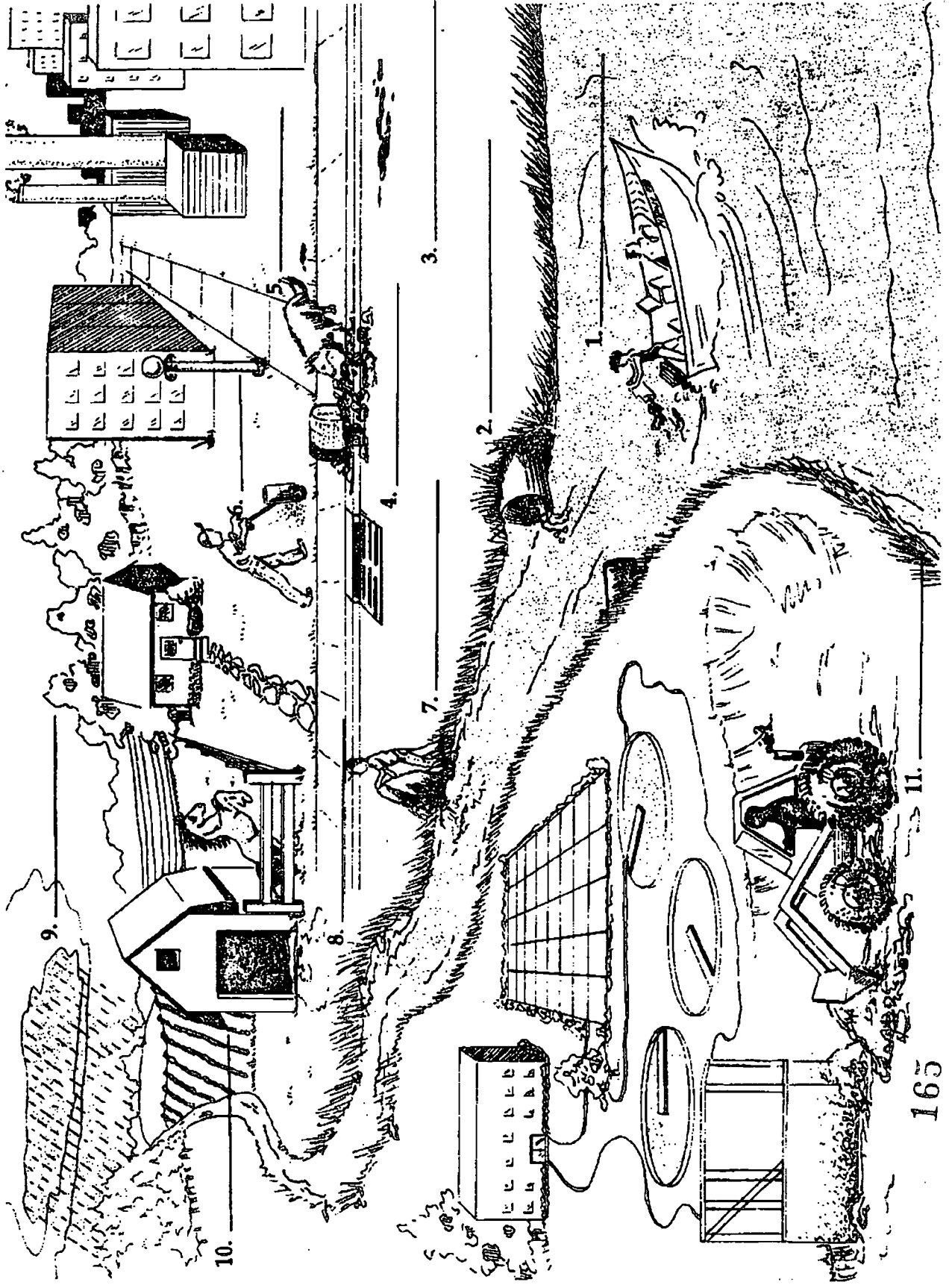


Golf Courses

South Carolina's Water Basins



Getting to the Source



EXAMPLES OF RUNOFF POLLUTION

- Pesticides
- Pet Waste
- Trash and Raw Sewage
- Stormwater Runoff
- Acid Rain
- Fertilizers
- Grass Clippings
- Litter
- Erosion
- Dumped Oil

The Water Table

6.nps.3

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 - 8

Focus: Understanding the water table and how water moves through soil.

Subject: Science

Materials: See itemized list below

Teaching Time: One class period

Vocabulary: Water table, groundwater, percolation, impervious, pervious

Learning Objective

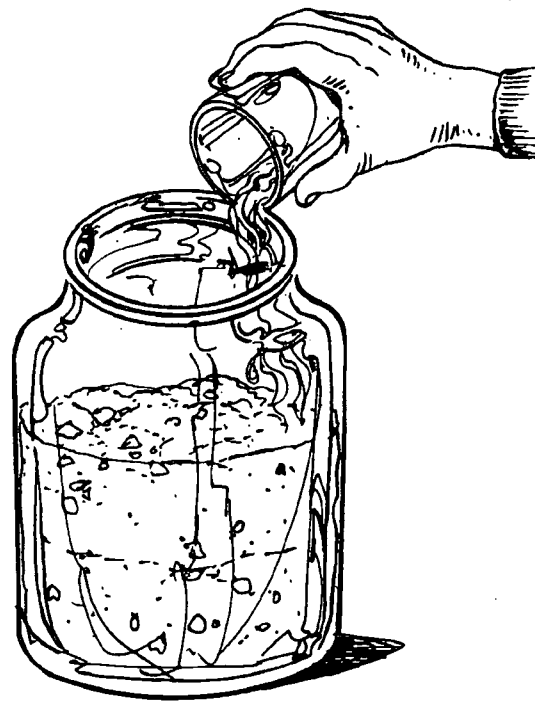
In this activity, students will create models of the water table and conduct an experiment to see how water moves at different rates through different types of soil. Students will discuss how the rate of flow through soil can affect the amount of pollutants that are filtered naturally by soil. Students will:

- see how water is stored in the ground
- see how water runoff and pollution move through soil.

Materials

See the illustration of the water table model on this page. You may present this as a demonstration or have students work in groups. For each group, materials include:

- wide-mouth glass jar (or a two-liter plastic soda bottle with the top cut off)
- a beaker, measuring cup, or any cup for pouring water
- crayon (dark color works best to mark on plastic) or permanent marker
- a mixture of sand and gravel (several cups)
- water (several cups)



Background

Precipitation falls into water or on land where it “runs off” of hard, or **impervious**, surfaces such as rock or concrete, or infiltrates soft, or **pervious**, surfaces such as soil or sand. If water moves downward, it can replenish water contained in the underground rock and sediment. This supply of water is referred to as “**groundwater**.”

Groundwater is water that has percolated into the ground and is held under the surface. Rain seeps through the top layers easily. The earth near the surface is loaded with tiny air spaces. Even rocks have cracks and pores through which water can find its way. But when water reaches clay or impervious rock, it will not sink any farther.



Japan uses 49.5% of its water for agriculture, 33.4% for industry, and 17% for homes. The United States uses 42% for agriculture, 46% for industry, and 12% for homes.

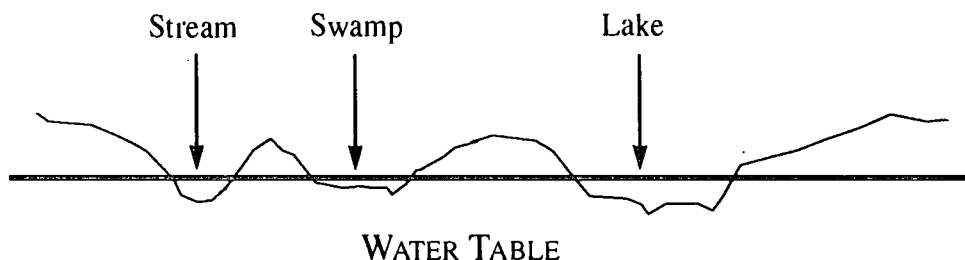
source: 1994 Environmental Almanac

As more water seeps or **percolates** into the ground, it begins to collect above the bedrock or dense soil. When the ground has as much water as it can hold, it is said to be saturated. Water that seeps into the ground fills the tiny crevices and the water level rises toward the surface as the spaces in the ground fill up. The uppermost level is called the **water table**. The area of dry ground above the water table is called the zone or aeration. After heavy rains, the table is nearer the surface, and in dry weather it drops again.

Learning Procedure

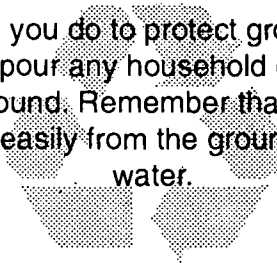
1. Fill a clear container (soda bottle or jar) three-fourths full of sand and gravel mix. Next, pour water down the side of the jar until the water level rises about half way up the side of the jar. This water level should represent the level of the water table. Use a crayon or marker to mark the present level. Show the students that if they add more water, the water table will rise.

2. Have students use their crayon or marker and press down on the sand in one spot down to the water table to show that wherever the land surface dips below the water table, groundwater flows out to the surface. This forms springs, swamps, or lakes. Explain to the class that during dry weather periods the water table level goes down and some streams and swamps may dry up as well. You may want to draw the water table illustration below on the board as an example.



Just Do It

What can you do to protect groundwater?
Never pour any household chemical
on the ground. Remember that chemicals
travel easily from the ground to our
water.



Extension Activity

1. Have students perform the following activity to see how water moves through different types of soil.

How Different Soils Affect the Movement of Water

Students will measure volume accurately, identify by texture three types of soil, and make visual observations about the water movement through the soil.

Materials

You will need a set of materials for each student or student group.

- 3 large polystyrene cups
- 3 plastic coffee can lids
- 3 squares cheesecloth
- rubber bands
- water
- thumbtack
- watch or clock
- sand
- clay
- gravel
- pencil
- 4 - 250-ml beakers or cut off soda bottles
- scissors
- measuring cup

This activity should be preceded by a discussion of types of soils, and how water is absorbed into the soil and moves, with time, around the soil particles.

Demonstration procedure:

1. Using a thumbtack, punch several holes in the bottom and around the lower part of each cup. Make sure students punch the same number of holes in each cup.
2. Place a square of cheesecloth over the bottom of each cup so it covers all the holes. Secure the cheesecloth with a rubber band.
3. Using scissors, cut a hole in the plastic coffee can lid so that the cup just fits inside. Place each cup in a lid, and place each lid over a beaker. (See the illustration for the demonstration set up.)

Label the cups A, B, and C.

4. Fill Cup A half full of dry sand, Cup B half full of clay, and Cup C half full of a mixture of sand, gravel, and clay.

5. Have students make a chart similar to the one below for recording their observations.

<u>Cup</u> A	<u>Time Water In</u>	<u>Time Water Out</u>	<u>Observations</u>
B			
C			

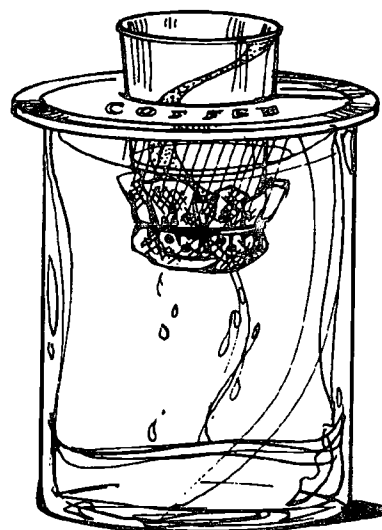
6. Pour 100 ml of water into the middle or center of each cup. Record the time when the water was first poured into each cup.

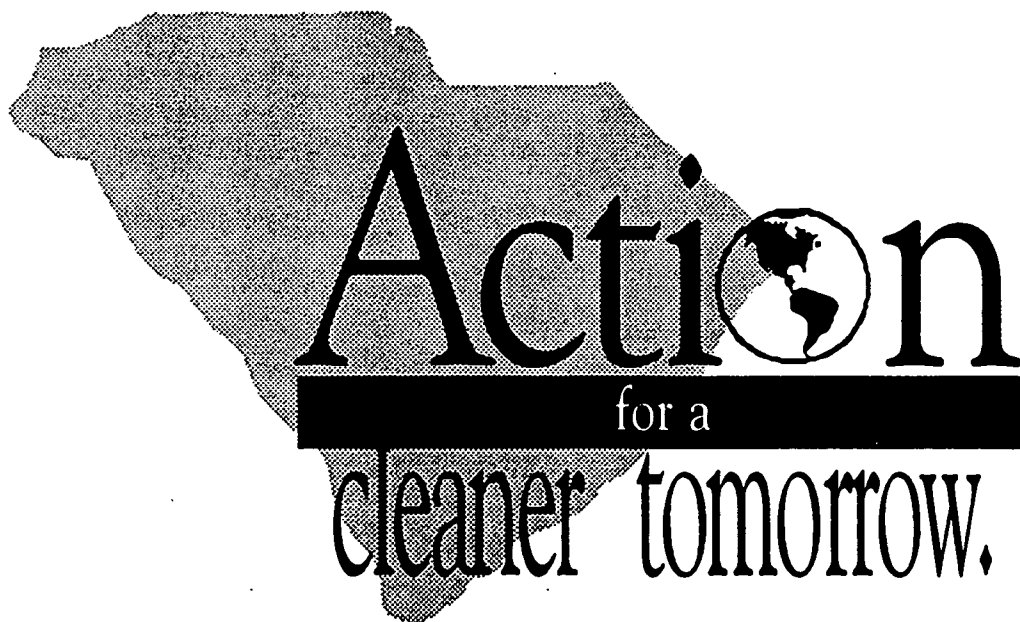
7. Record the time when the water first drips from each cup. Note the appearance of the water.

8. Allow the water to drip for 25 minutes. At the end of this time, remove the cups from the beakers. Measure and record the amount of water in each beaker.

Questions for the Class

Which soil sample is the most permeable? Which soil is the least permeable? How does the addition of gravel affect the permeability of clay? How does soil type affect the movement of groundwater? Can soil protect groundwater? Which one? How?





A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Water Filters

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6–8

Focus: Using filters to clean water

Subjects: Science, Health

Materials: Two 12 ounce plastic soft drink bottles per filter, paper coffee filters (two for each bottle), clean washed sand, assorted small rocks, poly fiber stuffing (pillow stuffing), paper towels, several milk jugs filled with muddy water

Teaching Time: One class period

Vocabulary: Source water, groundwater, surface water, filter



Learning Objective

Students will:

- discuss ways to clean water
- hypothesize which filter will do the best job
- observe experimental results
- form conclusions based on experimental results
- use experimental results to decide on additional experimentation.

Background

Read the Resource section on Drinking Water.

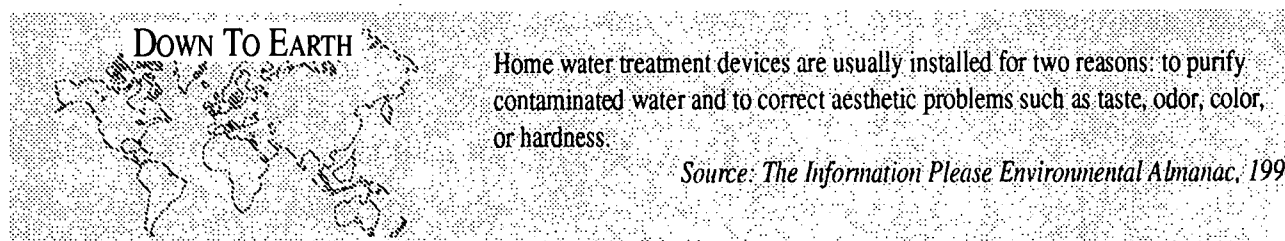
Fresh water can be found in three main places on earth: as a **surface water**, as a **groundwater**, or frozen as snow and ice. All of these **source waters** can be used for drinking water. Stop and think for a minute if you would be willing to drink water as it is found in a lake or stream.

Before the water comes out of the faucet in your home, it needs to be made safe to drink. Public

drinking water must meet the standards set by federal and state governments. The cleaning of water is done at a water treatment plant. The water treatment plant uses two basic techniques to clean and purify water for drinking. One method is to **filter** the water to remove dirt and other particles. The ancient Greeks wrote about pouring water through cloth to purify it. Some organisms that can cause waterborne illness are so small that they can pass right through filters. Water treatment plants can also clean water by treating it with a disinfectant to **kill harmful germs**.

Learning Procedure

1. Discuss the Background material about drinking water and where source water comes from in your area, i.e. is it groundwater or surface water? Ask the students if they would drink water right out of a lake or stream. Why not?
2. Discuss the purpose of a Water Treatment Plant. Review the two jobs of a Water Treatment Plant:



1) cleaning the water with filters, 2) disinfecting and preparing the water with chemicals.

3. Tell students that they are going to test several water filters. Prepare the water filters by cutting the bottom off of a 12 ounce soft drink bottle to form a funnel shape. (See the illustration.) Cut the neck and shoulders off of another soft drink bottle to form a cylinder with a bottom. Place the funnel (neck down) into the cylinder to form one complete filter. **DO NOT ALLOW STUDENTS TO CUT OUT THE BOTTLES!** This should be done by the teacher.

4. Prepare a set of four different filter setups for each team:

FILTER 1: Place enough poly fiber in the funnel to fill it to within one inch of the top. Pack the poly fiber down well.

FILTER 2: Place two coffee filters in the funnel. Place them so as to prevent any water poured into the filter from passing between the coffee filter and the wall of the funnel.

FILTER 3: Place small rocks into the funnel. Fill to within one inch of the top.

FILTER 4: Place a folded paper towel inside the neck of the funnel to prevent escape of sand. Fill the funnel with clean sand to within one inch of the top.

5. Line up the four types of filters on the demonstration desk. Ask the students to hypothesize which filter they think will work best. Why?

6. Pass around milk jugs of muddy water. Have each team pour some muddy water through each type of filter and observe what happens. Record your observations.

7. Have students report their results to the class and compare results. Which type of filter worked best? Why? What types of filters do Water Treatment Plants use?

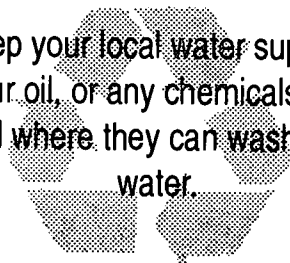
Extension Activity

Have the students design their own filters using the soft drink bottle setup. How would the teams design the best filters for cleaning water? What about using a combination of materials? Reiterate to the students that even though the filtered water *looks* clean, it is still not fit to drink and must be chemically treated to kill germs.



Just Do It

Help keep your local water supply clean.
Never pour oil, or any chemicals, out on the
ground where they can wash into our
water.



Take Me To Your Meter

6.DW.2

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Water conservation

Subjects: Science, Math

Materials: Meter reading worksheet (included)

Teaching Time: One class period

Vocabulary: Water treatment plant, distribution system, water meter, water conservation

Learning Objective

Students will:

- determine if they have a water meter and locate the meter
- determine the type of water meter at their home
- learn to read a water meter
- learn to use a water meter to measure water use
- examine a water bill and learn to calculate the cost of water.

Background

After the water leaves the **water treatment plant**, it travels along pipes in the **distribution system** to get to your home. It must pass through a **water meter** to measure the amount of water used in your home in order for a water bill to be calculated. Usually the water meter is located outside of the home at some point between the pipes running under the street and the pipe carrying water into the home.

If you have a well or a spring, you will not usually have a water meter. The water is yours to use without paying anyone. You may also not have your own water meter if you live in an apartment

building or a trailer park. All the water used is divided up among the users and each is charged an equal share. If you do not have a water meter, you will have to be more conscientious about water use in your home without being able to measure.

There are several kinds of water meters. Some meters are a single dial meter with all of the numbers displayed in boxes for tens, hundreds, thousand, etc. On this type of meter, only the one unit is displayed on the dial. Sometimes all of the numbers are displayed on the face and no dial is on the meter. Older style meters have a dial for every unit component of a number, i.e. a dial for ones, a dial for tens, a dial for hundreds, etc. These six dial meters are a bit more difficult to read. To read this style of water meter, locate the dial which reads the largest (usually 100,000) number, then proceed around the dial reading the small dials in a clockwise direction. At each dial, look and see what number the needle is pointing to. If the needle is between two numbers, chose the smaller number (except when between 9 and 0). It is important to learn to read your water meter in order to practice **water conservation**.

Learning Procedure

To do this lab, the student will need to find out: 1) if they have a water meter at home, 2) where the water meter is located, 3) what type of dial system they have on their water meter, 4) how to read their own water meter, and 5) how to use their water meter to measure water usage and conserve water.

CAUTION: The metal box that holds the meter has a heavy lid that can fall down on a student's hand. The area inside the box is a perfect habitat for all



In the past century, every major U.S. river has been harnessed for irrigation, hydro electric power, flood control or a combination of these purposes.

Source: *The Information Please Environmental Almanac, 1994*

6 – 8
PAGE
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kinds of creatures, so the students should be prepared to see toads, roaches, etc. Along with these other insects, this dark habitat is a perfect spider location and may contain a dangerous spider such as the brown recluse spider. Therefore, parents should be involved in the location and reading of the meter and appropriate cautions should be pointed out before beginning.

Part I

As homework, have each student find the answers to the first three questions above. Bring these answers to class on the day that the class learns to read the different types of water meters.

Part II

1. Using the enclosed worksheet, look at the first example of a water meter. Notice that it is a six-dial style of meter. Each dial represents a unit of a six digit number (100,000). Locate the dial representing the hundred thousand digit. **Ask:** what number does the needle point to? (*The standard rule is that if the needle is between numbers, always choose the smaller number except when the dial is between 9 and 0. In this case, the smaller number is going to be the 9.*)

2. Locate the dial for the ten thousand digit. Read it. Locate the dial for the one thousand digit. Read it. Continue until all of the dials have been read. What is the total number for the meter. Does this meter read in gallons of water used or cubic feet of water used?

3. Look at the example of a single dial meter. This is more common in newer neighborhoods. On this meter, all of the numbers are already listed, except for the ones. The dial is currently registering this number. As above, if the needle is between numbers, choose the smaller number except in the case of a needle between 9 and 0. Record the number from this meter.

4. Practice reading different styles of water meters with the attached work sheet.

Part III

Once you have developed a proficiency with water meter reading, it is time to put this to good use to discover how your family uses water. With *Adult Supervision*, perform the following homework assignments:

A. Turn off all of the faucets both inside and outside of your home. Read your water meter. Go inside and flush one toilet. Go back outside and read your water meter. How much water was used?

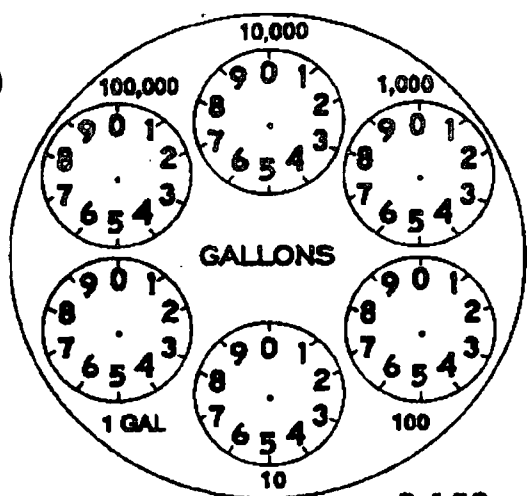
B. Repeat this assignment in the morning. Choose either brushing your teeth or taking a shower for your measurement. Make sure no other water is used during this time so that you can get an accurate measurement.

C. Turn off all of the water faucets both inside and outside your home. If you have an automatic ice maker on your icebox, have an adult help you to turn it off also. Try to make sure no one needs to use any water for a while, including using the bathroom. Take a meter reading. Wait one half hour and take another reading. Did you meter record any water usage? Check again to make sure no one used any water. If your meter indicates some water was used, you may have a dripping faucet or a leaking toilet somewhere in your house. Estimate how much water is lost in 24 hours. See if you can find a leak.

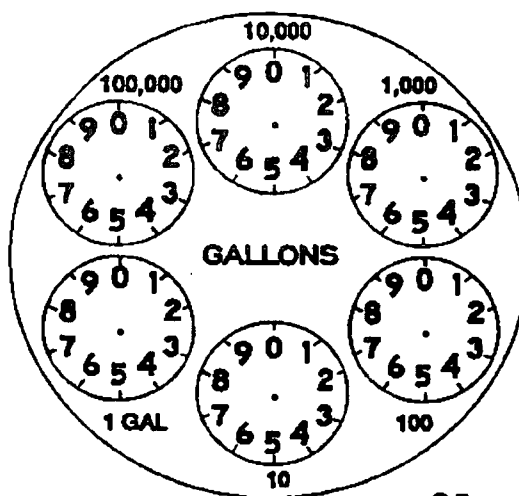
D. Obtain a copy of your water bill. What is the total cost for the current month? How much water was used? What other charges are added to your water bill? If your sewer bill is part of your water bill, what percentage is charged? As a class, find out if your water supplier averages your monthly water use over a one-year period.

Extension Activity

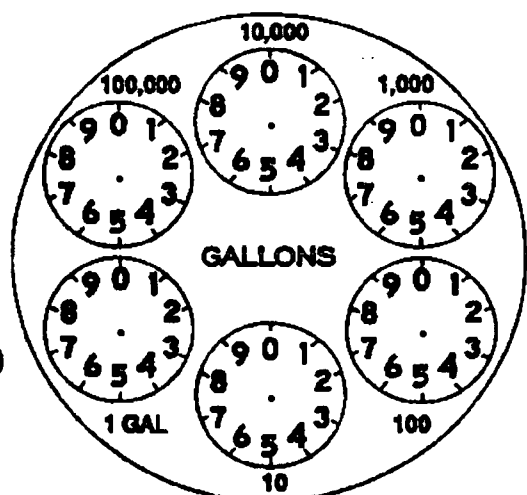
Find out if your toilet is leaking by putting a few drops of bright colored food coloring into the tank behind the seat. Do not flush the toilet for at least 20 minutes. After the 20 minutes, check to see if any of the color has "leaked" into the bowl of the toilet. If it has, you have a leak to stop. Sometimes you can hear water running when near a toilet. This also indicates a leak.



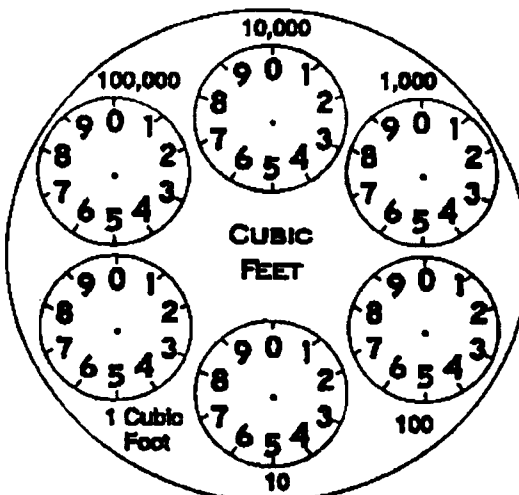
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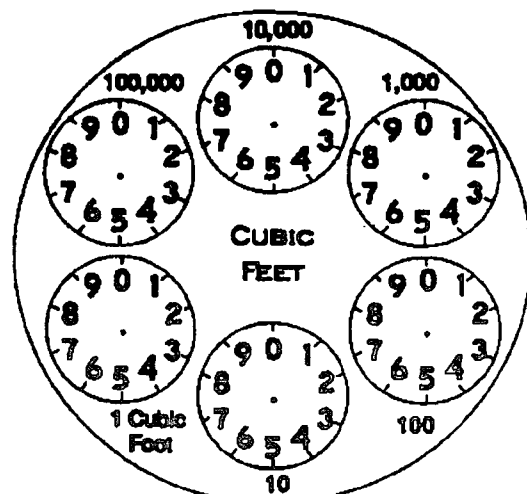
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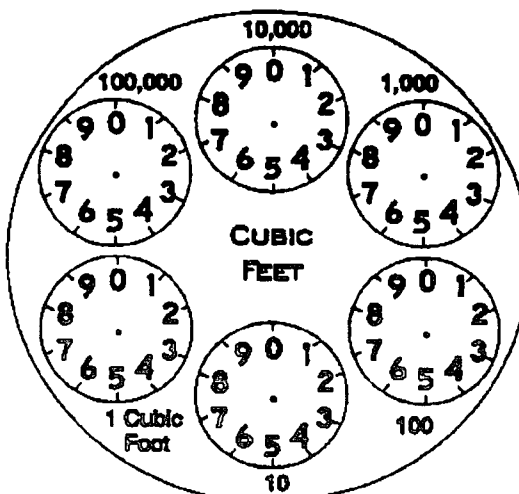
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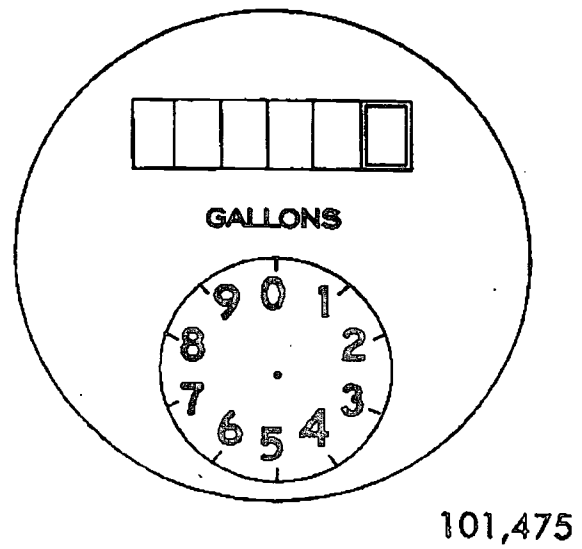
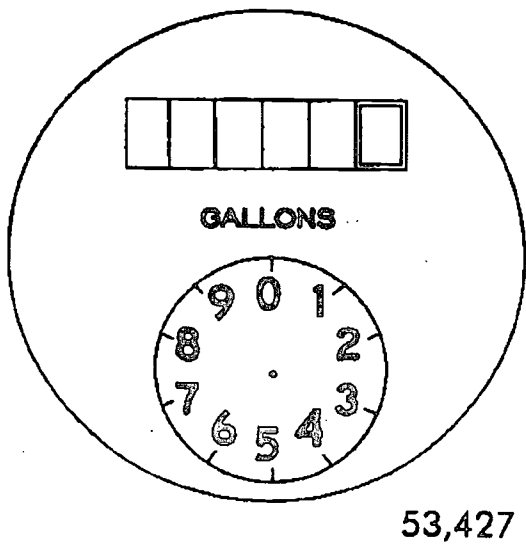
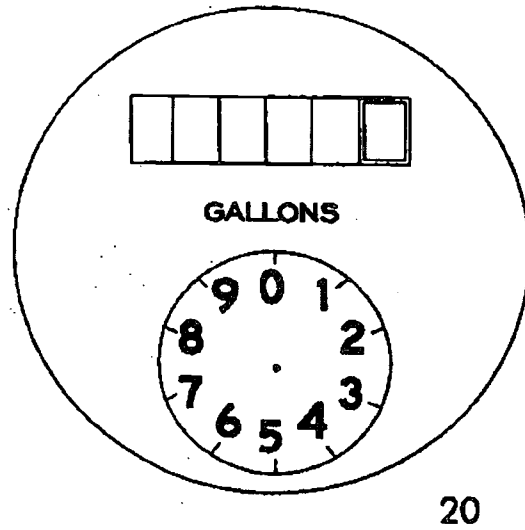
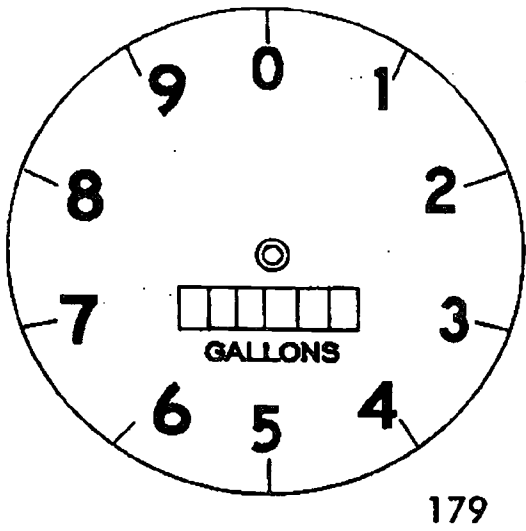
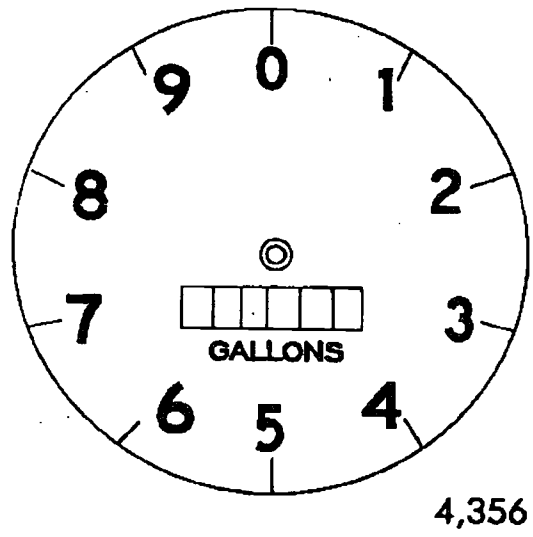
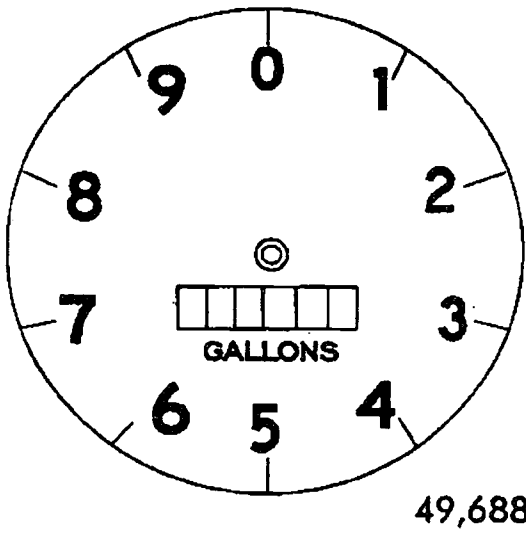
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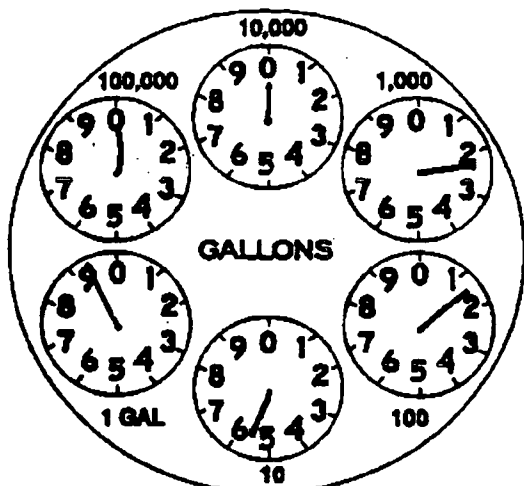


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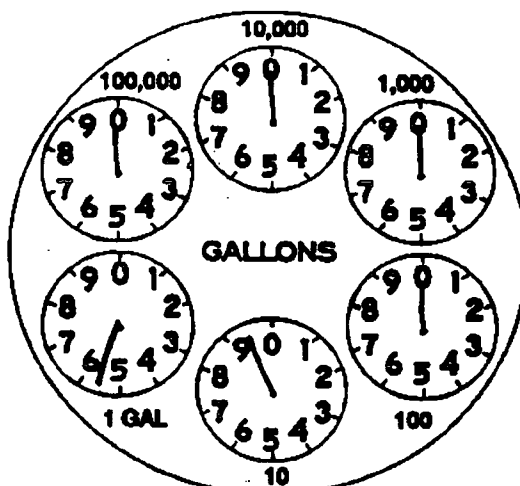


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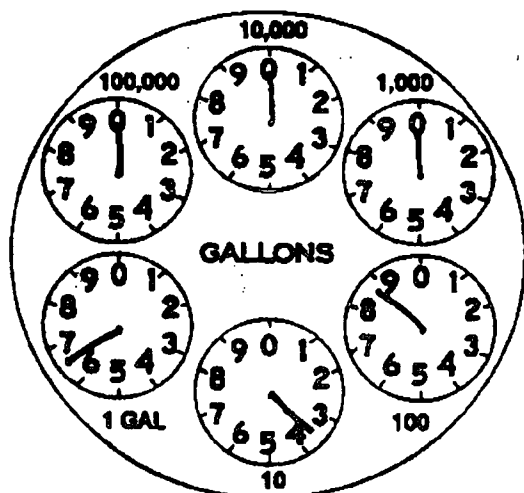




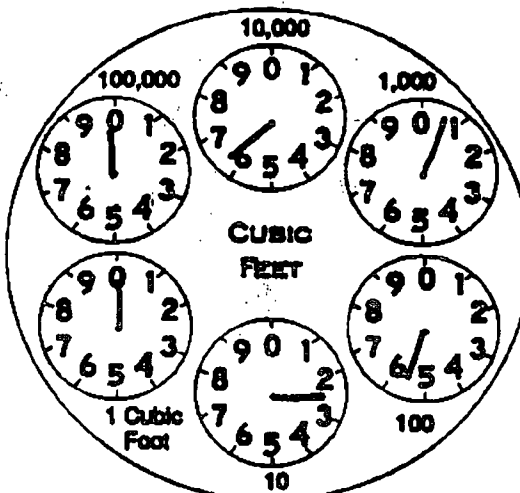
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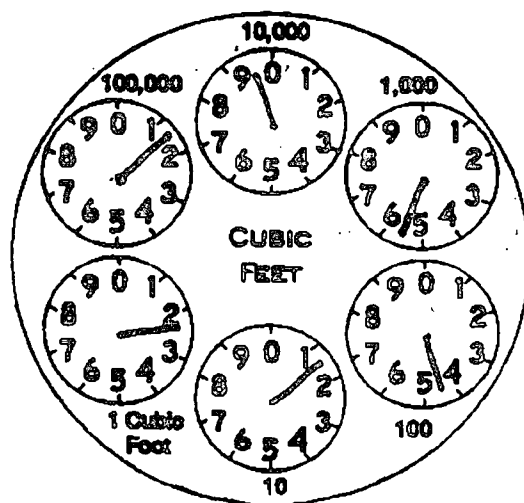
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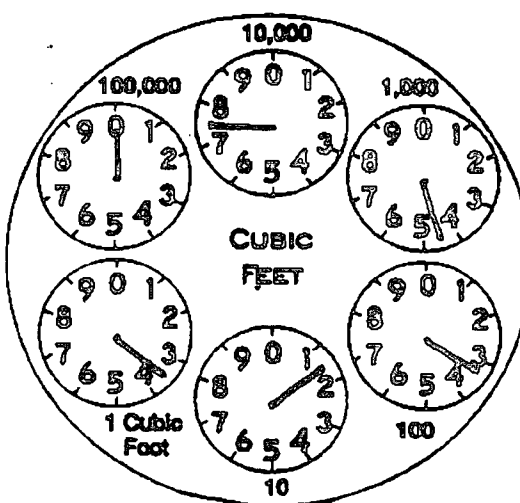
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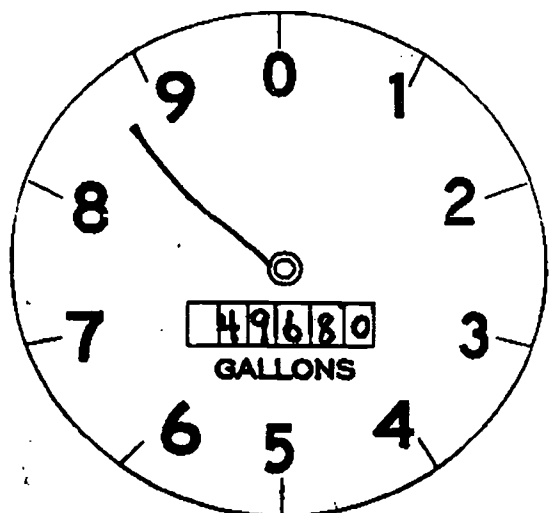
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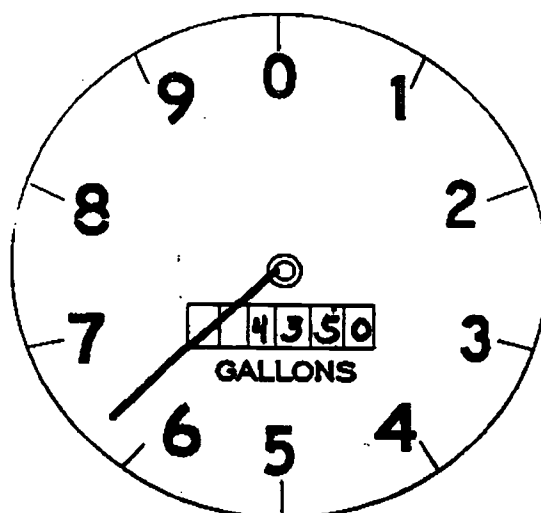
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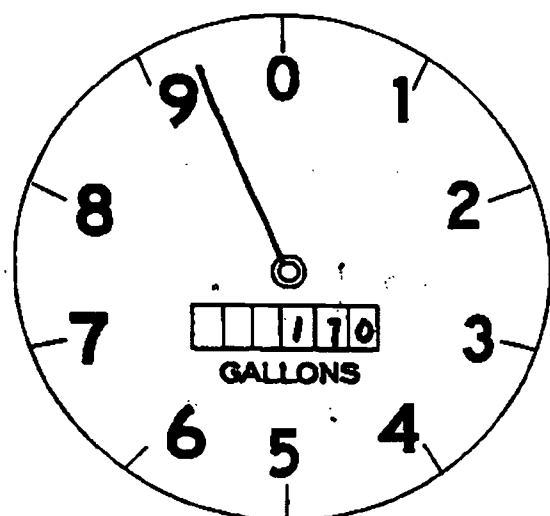
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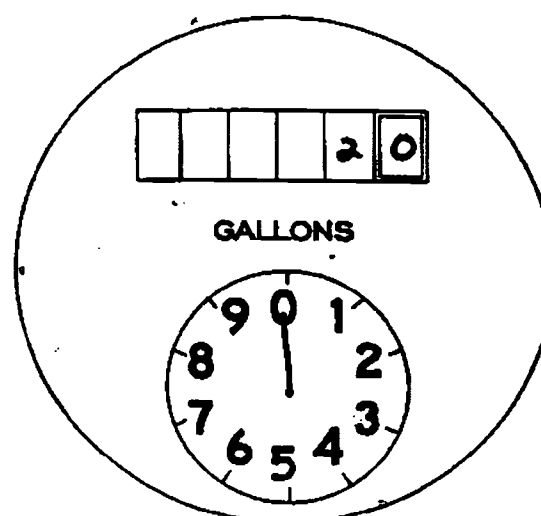
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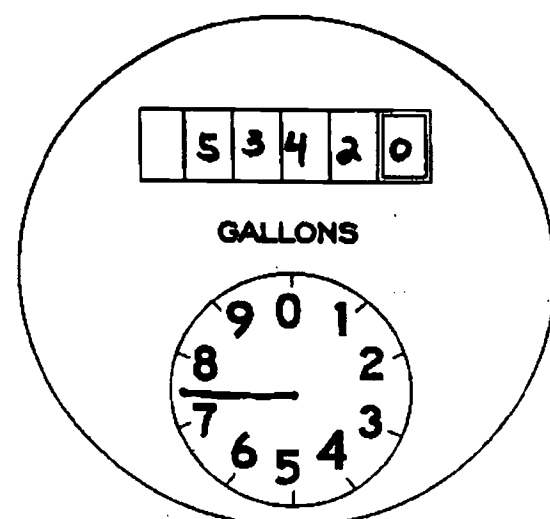
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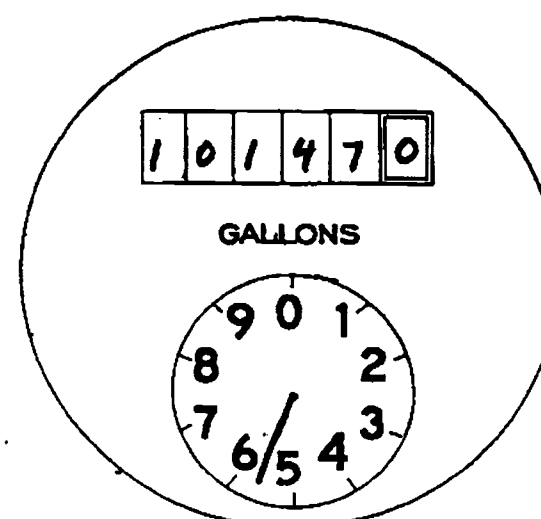
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53,427



101,475

Salt Water & Sinkholes

6.DW.3

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: Water conservation

Subjects: Science, Geology, Hydrology

Materials: Two clean plastic two liter soft drink bottles per team, clear plastic soda straws, duct tape, aquarium gravel, red food coloring, soap bottle pump, cardboard box from a case of soft drinks, aluminum foil, dirt, balloon, funnel, water, bucket, plastic or paper houses

Teaching Time: One class period

Vocabulary: Groundwater, recharge, aquifer, salt water intrusion, sinkhole

the groundwater stores, it might be possible to withdraw all the water stored in an aquifer. As stewards of the Earth's fresh water stores, we must be careful not to draw more water out than can be naturally replenished through recharge.

If water is drawn out of the aquifer faster than it can be replenished, the water table in the aquifer can drop below sea level. In areas along the coast, salt water will seep in to fill the spaces which once held fresh water. This is called **salt water intrusion**. Salt water intrusion causes the water drawn up from wells to become slightly salty or brackish and unfit for drinking. Hilton Head Island, South Carolina is currently dealing with salt water intrusion problems and there are no easy solutions. The best management practice is to maintain a level of water withdrawal which keeps up with the recharge.

In South Carolina, most of the geologic layers under the ground are solid rock or mixtures of different types of soil such as sand and clay. In some parts of the United States, such as Florida, the underlying rock is limestone. If the groundwater is slightly acidic, it can dissolve the limestone forming caverns under the ground. As long as these caverns are filled with water, the surface is supported. But if all the water is pumped out of a limestone aquifer, it is possible for the surface to collapse downward to form a **sinkhole**.

Learning Objective

Students will:

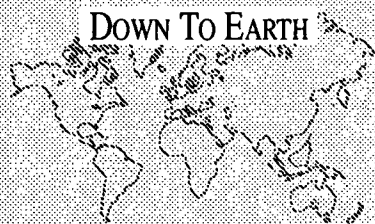
- observe what happens when water is drawn out of an aquifer
- build a model and observe an example of salt water intrusion
- build a model and observe how a sinkhole is formed
- examine a real life water management problem.

Background

In South Carolina 60 percent of the population gets their drinking water from **groundwater**. Rain and other precipitation falls on the surface and either runs off into surface water bodies or soaks down to become part of this underground store of water. We use the term **recharge** to describe the replenishing of groundwater by precipitation soaking down. Areas that contain supplies of groundwater are called **aquifers**. Without a way to replenish water to

Learning Procedure

1. Divide the students into teams of four and give each team two clear plastic two-liter soft drink bottles labeled "A" and "B," a straw, and some duct tape. You should have already poked a small hole in each bottle about halfway down the bottle. The



The Rio Grande and one of its tributaries, the Rio Conchos, are at the top of North America's list of most endangered and threatened rivers.

Source: *The Information Please Environmental Almanac, 1994*

6-8
PAGE
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students should insert each end of the straw into a bottle so that the two bottles are connected by a straw. Seal off the point where the straw and bottle join with duct tape so that no water leaks from the straw holes.

2. Fill bottle "A" with aquarium gravel to a level above the straw hole. (This can be done the day before as preparation for the experiment.) Fill each bottle with water to just above the gravel level. Bottle "B" will contain only water and represents an aquifer.

3. Insert the soap dispenser pump in gravel bottle "A" and pump the water out into the bucket. Note how the water moves from bottle "B" through the straw to replenish the water that is drawn out of bottle "A" by the pump. As long as water is added to bottle "B," we can continue to draw as much as we want from bottle "A." This is much the same as might happen if water were drawn out of an aquifer at the same rate as recharge was added.

If no water is added to bottle "B," continued pumping will remove all of the water out of bottle "A" and the water level in bottle "B" will drop below the straw so that bottle "A" no longer has access to the water in "B."

4. Refill both bottles up to a level above the gravel. Make the water in bottle "B" represent salt water by adding a few drops of red food coloring so that we can see what happens to this water. Pump bottle "A" to withdraw water. What happens? As fresh water is drawn out of bottle "A," salt water (red) moves across the straw and replaces the fresh water and the well now pumps water that is too salty to drink. This is salt water intrusion.

5. Create a sinkhole by setting up the following model:

A. Open one end of a cardboard box used to hold a case of soft drinks by cutting both edges of one side down to the bottom of the box and folding the resulting flap down. Line the box with foil to make it water resistant.

B. Fill the box with loose dirt. Fill a balloon with water and close the end with a rubber band. This represents an aquifer.

C. Bury the balloon in the middle of the box close to the surface, but allow the sealed end to stick out of the dirt on the end which has been opened. Place some model houses on top of the dirt to simulate a village.

D. Place the bucket under the open end of the box. Open the balloon and gradually drain the "aquifer" into the bucket. When all the water has been drained out of the balloon, what happens?

E. Discuss what would happen to a limestone aquifer that was totally emptied? What would happen to the houses on top of this aquifer? What are some ways to prevent both salt water intrusion and sinkholes?

Extension Activity

Have each team divide into two units, one unit representing farmers whose only source of income is their crops and one unit representing water managers who must make sure that all the groundwater is not used up. Imagine a three month drought has occurred. The farmers need more and more water out of their wells to sustain their crops. The water managers have to maintain the aquifer.

Have the teams list all the possible solutions to good water management so that the crops don't fail but also the aquifer is not emptied. Have each team choose a solution which agriculture and water managers can agree on. Report all of the team solutions to the class.

South Carolina's Bodies of Water

6.DW.4

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6–8

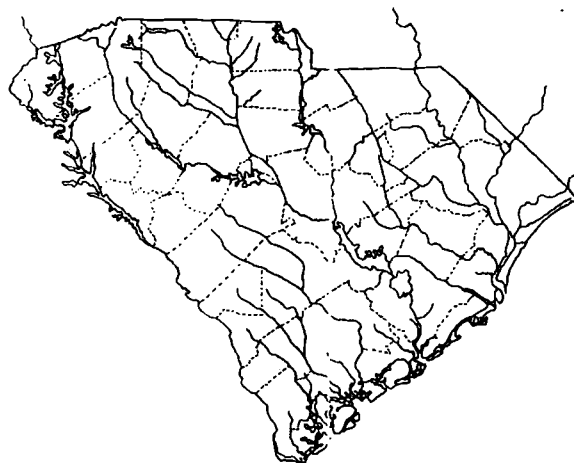
Focus: South Carolina's rivers, lakes, and reservoirs

Subjects: Geography, Social Studies, Language Arts, Science

Materials: Map of South Carolina rivers, lakes, and reservoirs (included), colored pencils, markers, crayons, a classroom wall map of South Carolina

Teaching Time: One class period

Vocabulary: Source water, watershed, runoff



Learning Objective

Students will:

- locate 11 South Carolina cities on a map
- locate their home county on a map
- locate 16 South Carolina rivers on a map
- locate 12 South Carolina lakes on a map
- locate two South Carolina reservoirs on a map.

Background

Water is one of South Carolina's most precious resources. We have miles of beautiful rivers and countless lakes for boating, fishing, and swimming. Not only are these waterways enjoyable because of their sheer beauty, but many of these water bodies also provide the **source water** for much of our state's public drinking water.

The best way to learn the names and locations of South Carolina water bodies is to visit each one. This might take years, so the next best way is to practice the names and locations with maps and map associated activities.

It is also important to know the location of these water bodies so that we may better understand about watersheds. A **watershed** is a region of land that drains all of its **runoff** into a specific river or other body of water. When the body of water receiving the runoff is also a water source for public drinking water, it becomes very important to protect that watershed so that it has the very best water quality.

Learning Procedure

Students may work singly or in teams of two. Use the unlabeled South Carolina map and some colored pencils or markers. Have a large scale South Carolina map for easy access. Have students label the following items on their map:

1. Color your home county yellow.
2. Find and label the following South Carolina cities as location references for the water bodies:

Aiken	Charleston	Myrtle Beach
Anderson	Columbia	Spartanburg
Beaufort	Florence	Sumter
Camden	Greenville	



In South Carolina, the per capita water consumption is 1,916 gallons. The average amount of water used per day is 6,820 million gallons.

Source: *The Information Please Environmental Almanac, 1994*

6–8
PAGE
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3. Label and color blue the following South

Carolina rivers:

Ashepoo	Combahee	Enoree
Savannah	Black	Congaree
Pee Dee	Tyger	Broad
Cooper	Saluda	Waccamaw
Catawba	Edisto	Santee
Wateree		

Just Do It

Be aware that anything you pour on the ground — oil, fertilizers, chemicals — can end up in your local stream, river, or lake!

4. Label and color purple the following South

Carolina lakes and reservoirs:

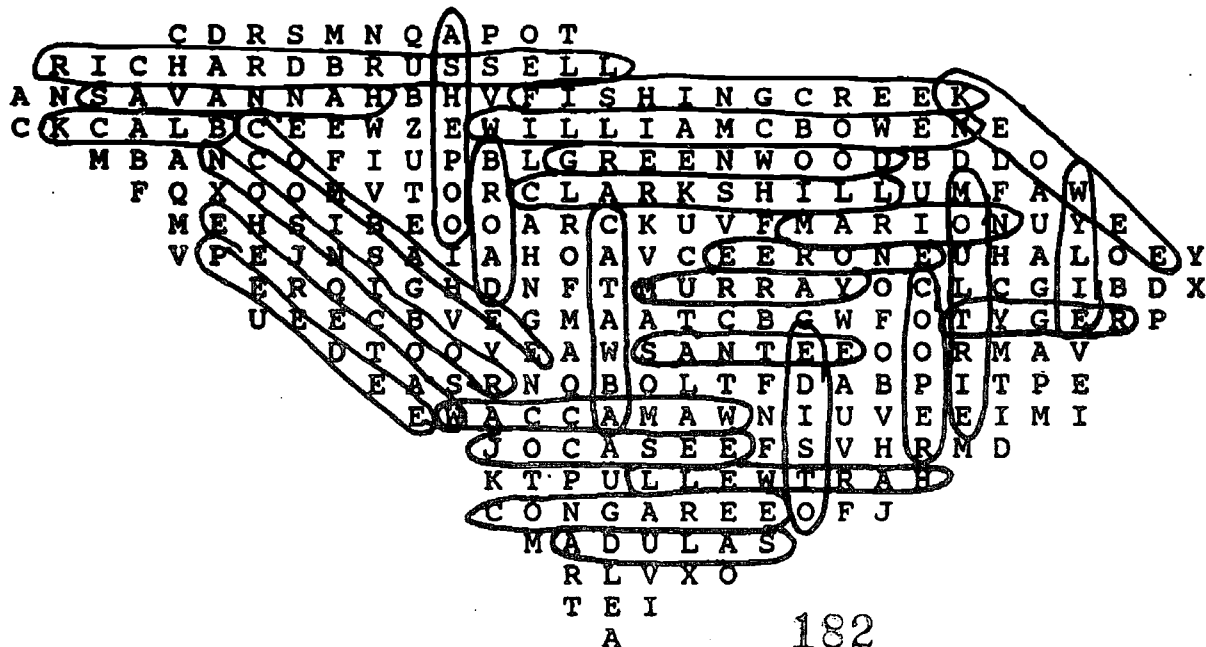
Clark's Hill Reservoir	Lake Moultrie
Fishing Creek Reservoir	Lake Murray
Lake Greenwood	Richard B. Russell
	Lake
Lake Hartwell	Lake Robinson
Lake Jocasee	Lake Wateree
Lake Keowee	Lake William C.
	Bowen
Lake Marion	Lake Wylie

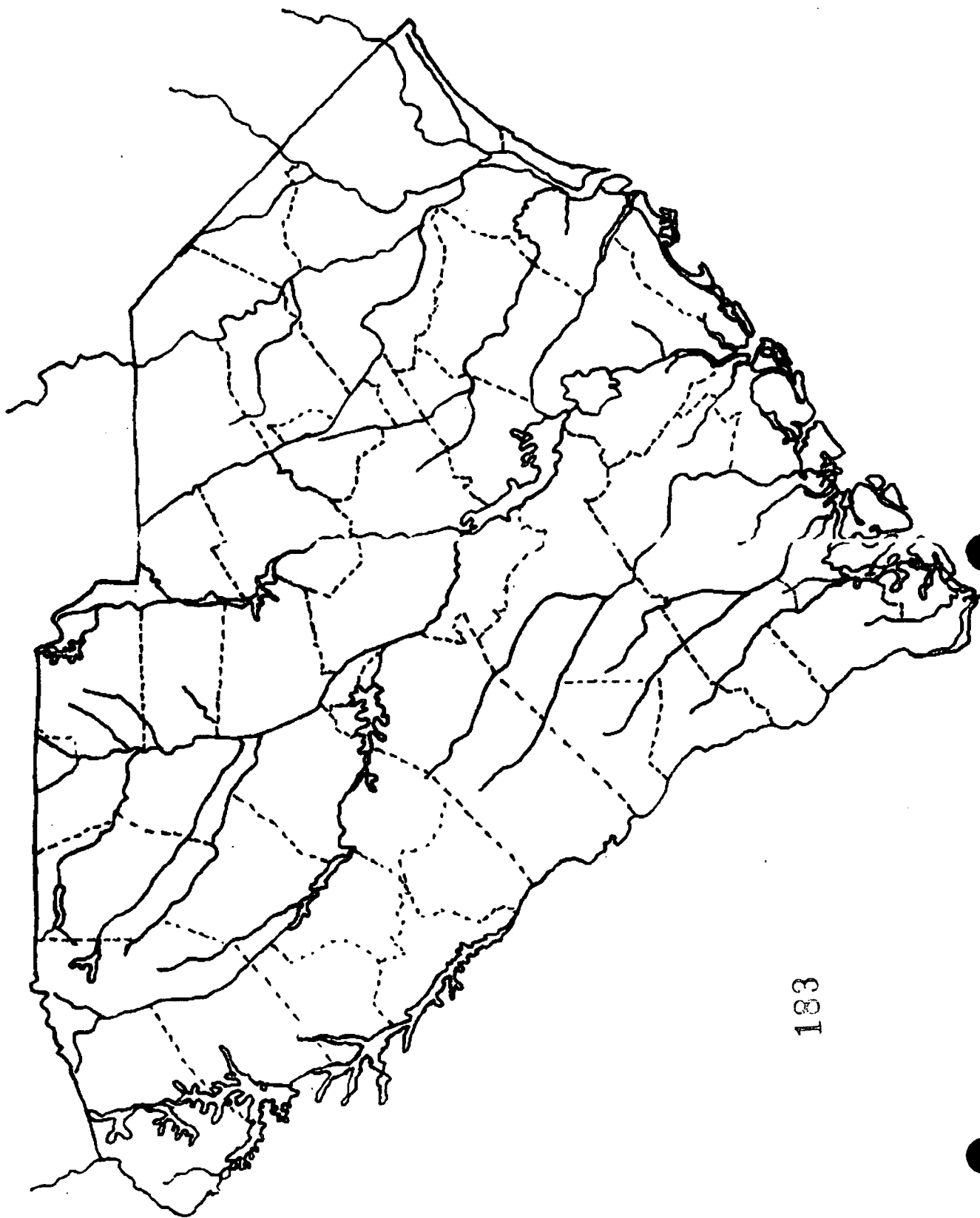
5. Give a copy of the word search to each student

and have them use the water bodies listed in

Numbers 2 - 4 to complete the work sheet.

WORD SEARCH KEY





183

184

NAME: _____

South Carolina Water Bodies Word Search

A C R I S C A B F V
 C H A V L A Q M P V
 C D R A N C O H E P U
 R S D N E O O S J R E U
 M B A E F M I N Q E D
 N R H W I V B S I C T E
 Q U B Z U T E A G B O A E
 A S H E P O O I H V O S W
 P S V W B R O A D E Y R A J K C
 O E F I L C A H N G E N C O T O M
 T L S L R A C A T A W B A S L A U V I
 H I E R K V M A S O M S L A U V I
 I A E K U C U T A L A E L R L X
 N M N S V E R C N T W E E E A O
 G C W H F E R B T F N F W E S
 C B O I M R A G E D I S T O
 R O O L A O Y W E A U V R F
 E W D L R N O F O B V H A J
 E E B U I E C O O P E R H
 K N D M O U L T R I E M
 E L F N H C Y M T I D
 O A U A G G A P M
 W Y L I E V E I
 E O B R
 E D P
 Y X

Can you find the names of 29 South Carolina rivers, lakes, and reservoirs?

The names can appear up and down, sideways, or on a slant. They can be spelled forwards or backwards. See how good a detective you can be ...

Power in South Carolina

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 4 - 5 & 6 - 8

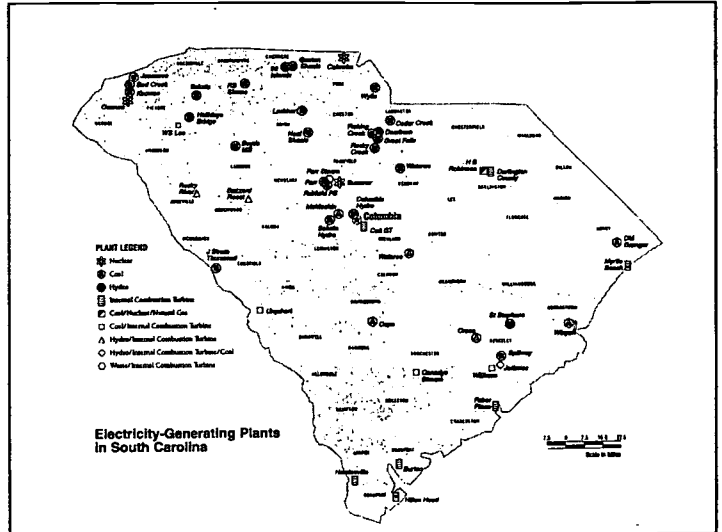
Focus: The various forms of energy used to produce electricity in South Carolina.

Subject: Science, Social Studies

Materials: Handouts included with this lesson

Teaching Time: One class period, plus student work

Vocabulary: fossil fuels, nuclear reactor, nuclear fission



Learning Objectives

In this lesson students will interpret charts, graphs, and illustrations to discover the story of power in South Carolina. Students will:

- see how electricity is generated and distributed in South Carolina.

Materials

Handouts "Power in South Carolina"

Copies of "The Energy FactBook: A Resource for South Carolina" (Optional: These are available from the S.C. Department of Health and Environmental Control's Resource Center, 1 800 SO USE IT, or the State Energy Office, 1 800 851 8899.)

Background

excerpts from "The Energy FactBook: A Resource for South Carolina"

South Carolina is a growing state. As our economy has developed, so too have our energy needs. In the last several decades, only four states have had higher energy use rates than we in South Carolina have had.

While we use energy in every sector of the economy, industry uses the most. It takes large supplies of energy to run the mills, factories, and farms that make our state prosper. In 1991, industry accounted for 40% of the state's energy use.

The transportation sector is the second largest user of energy, using 27 % of the state's total use. As primarily a rural state, South Carolina is state of drivers. It takes nearly 2 billion gallons of gasoline a year to keep South Carolina moving.

In our homes, we use 20% of the state's energy and the commercial sector uses the other 13%.

South Carolina does not have many natural energy resources of its own. The gasoline and other fossil fuels that make our economy grow must be imported from other states and countries.

Through science and conservation, we are now using proportionately less fossil fuels. In 1990, over one-third of the state's energy needs were met by energy resources other than fossil fuels.



The United States Environmental Protection Agency (EPA) estimates that computers account for 5 percent of commercial electricity use. New computer chips that "sleep" when not in use are expected to save 50 to 70 percent of this energy.

source: 1994 Environmental Almanac

Learning Procedure

1. **Ask the class:** When we switch on a light, what is the source of this power? (*Students may say power lines or power plants in general or they may be familiar with a local plant.*)

Ask: How was this power created? (*Review with students the basics of electric power generation. You may use videos, such as Santee Cooper's PowerHouse Tour to review the generation process. The illustration, Producing Electricity, included with this lesson gives the basics.*)

Ask: What can we tell about the different types of fuel sources that are used to produce electricity? (*They each create heat that is used to create steam that turns the turbine that creates electricity.*)

2. Tell the class that there is a lot that you can learn about power in South Carolina from interpreting charts, graphs and illustrations, just the way they interpreted the basic illustration, *Producing Electricity*.

Give each student or small groups of students a copy of the handouts, *Power in South Carolina*, and have them read the text and interpret the graphics to answer the questions and learn more about power in our state.

Extension Activities

1. Have students research an energy source – coal, oil, natural gas, nuclear, solar power, wind, etc – used in creating energy. Students should be encouraged to find:

- How was it formed (for fossil fuels) or the process that causes it (solar, etc.)
- The availability in our state, country, world
- Environmental advantage/disadvantages.

2. Have students consider a good way to reduce energy use in the state and then write several paragraphs to explain. For example, they may suggest the use of more public transportation to reduce energy used for transportation (petroleum), or ways to lower residential energy use through use of solar heating or other efficient usage practices, or ways factories could save energy.

3. Have students write letters to the utility company that supplies their electricity asking about how power will be supplied in the future.

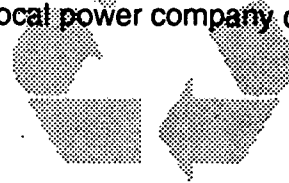
Does your power company have any investments in renewable energy or other alternative energy technology? Why or why not?

4. Plan a field trip to a power generating facility in your area or invite a representative to come to your school.

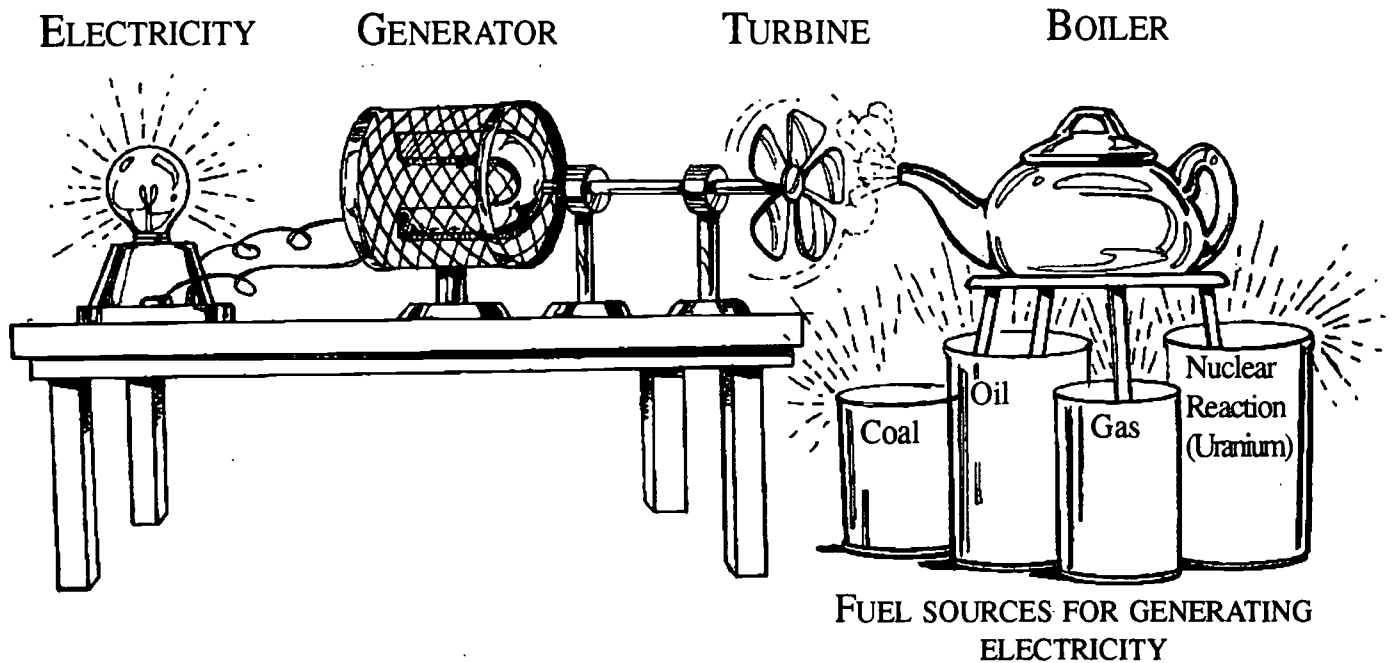
Just Do It

Use energy wisely at home. Conduct a home energy audit to determine if your home is energy efficient.

Your local power company can help.



Producing Electricity



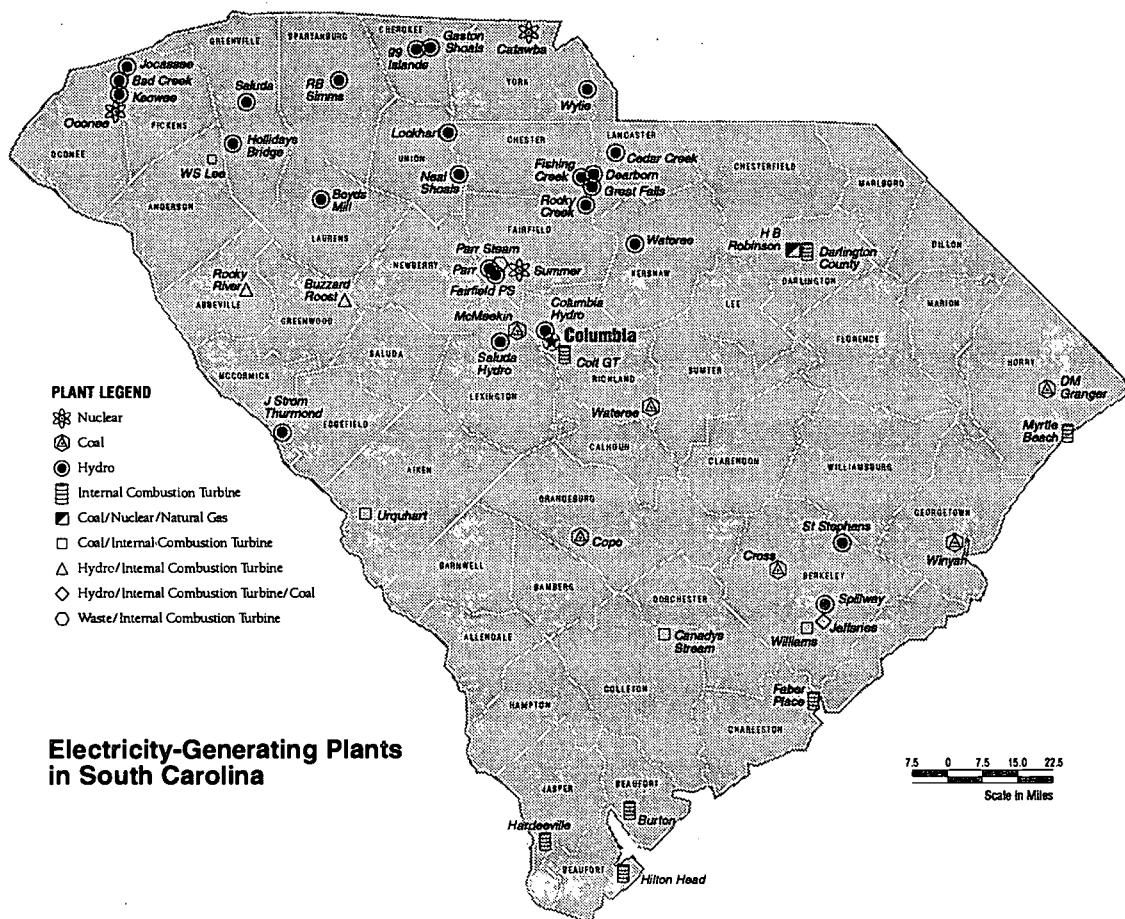
PRODUCING ELECTRICITY

Several fuel sources are used in South Carolina's electricity generating plants. Each of these fuel sources provides the heat that is used to create steam. This steam provides the power to turn the turbine that spins the magnet inside the coil, creating electricity. In South Carolina, nuclear fission creates the heat that provides about 60 percent of the electricity.

In hydroelectric facilities, no heat is needed. Falling water is used to spin the turbine.

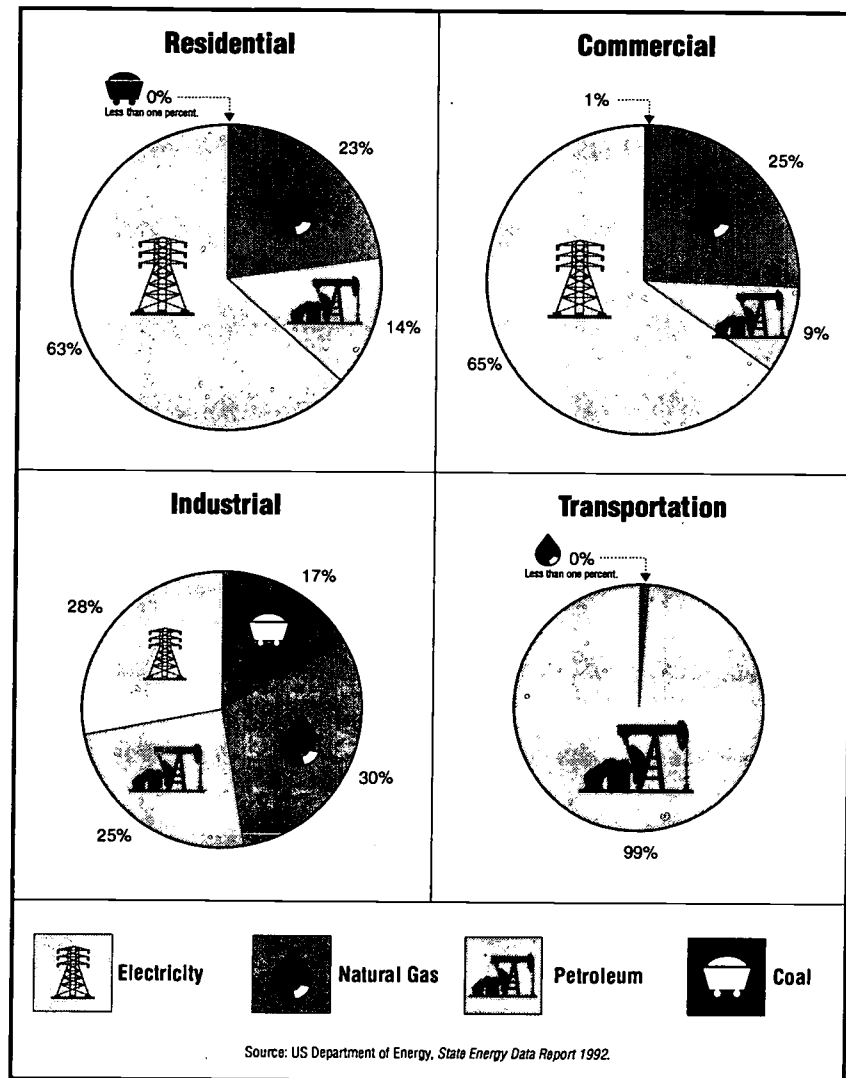
POWER IN SOUTH CAROLINA

Graphs, charts and illustrations about
energy in South Carolina



South Carolina's

net energy consumption
by sector – 1992



Use the charts above to answer these questions about energy in South Carolina.

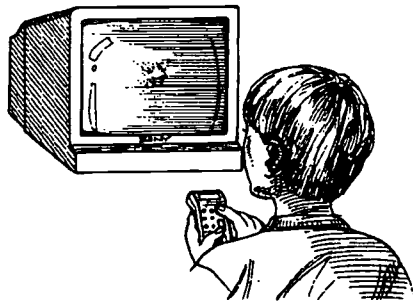
1. What are the sectors or categories of energy consumers in South Carolina?

2. What are the four types of energy resources listed on the charts?

3. Which sector uses the largest percentage of petroleum? _____

Why would this sector use so much petroleum? _____

4. Which sector uses the largest percentage of natural gas? _____

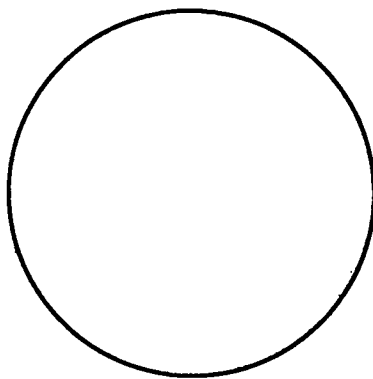


Getting to know electricity in South Carolina

Use the information on the
following pages of the *Energy
FactBook* to answer these

1. How many power plants are there in South Carolina? _____
2. How many nuclear plants are there in South Carolina? _____
2. What percentage of South Carolina's electricity is generated by nuclear power? _____
3. How many exclusively hydro plants are there in the state? _____
4. What percentage of the state's power comes from plants fueled by petroleum, natural gas or water?

5. What investor-owned company provides the most power to the people in this state? _____
6. Draw and label a pie chart that shows how electricity is generated by SCE&G.



7. What is South Carolina's public utility company? _____
8. How many people are served by this public-owned utility? _____
9. What percentage of electricity generated in the state is used by private homes? _____
10. What are "electric cities" in South Carolina? _____

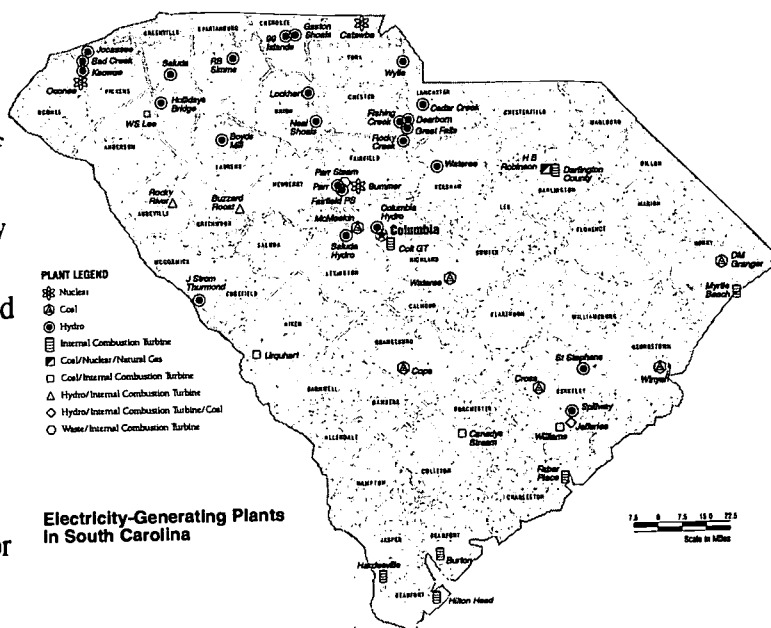
Electricity In South Carolina

reprinted with permission from the *Energy FactBook*

South Carolina's use of electricity continues to increase. In the past twenty years, the state has more than tripled the amount of electricity produced.

As the state's economy has grown, so has its need for electricity. As the map shows, the state has 59 power plants.

In 1991, these plants generated almost 80 billion kilowatt-hours of electricity. Nearly two-thirds of this electricity came from nuclear power plants. Coal-fired plants produced almost all of the remaining electricity. Less than 5% of our electricity comes from plants fueled by petroleum, natural gas or water.



SOUTH CAROLINA'S UTILITIES

South Carolina is served by investor-owned and municipally-owned utilities as well as rural electric cooperatives.

THE INVESTOR-OWNED UTILITIES

Four investor-owned utilities serve South Carolina: South Carolina Electric & Gas (SCE&G), Duke Power Company, Carolina Power & Light (CP&L), and Lockhart Power. These utilities have an assigned service territory, an obligation to serve, and are regulated by state commissions and federal regulations. Each is owned by millions of small investors who have stock in the company.

With nearly half a million customers (447,000 in 1991), SCE&G is the primary supplier of electricity in our state. It maintains 17,000 miles of transmission lines and 3,000 miles of distribution lines. Of the electricity generated by this utility, 66% comes from coal, 25% from nuclear fuel, and 9% from water power, internal combustion or other sources.

Duke Power Company, headquartered in Charlotte, NC, serves nearly 340,000 customers in South Carolina's Upstate region. Duke also operates more than 2,000 substations and switching stations interconnecting some 13,000 miles of transmission lines and 67,000 miles of distribution lines.

Over 60% of the electricity produced by Duke Power comes from nuclear fuel. Thirty-seven percent of the electricity is generated by coal and 3% comes from water power, internal combustion or other sources.

Carolina Power & Light, also headquartered in North Carolina, operates two

plants in our state, both in Hartsville. CP&L's service area covers one-fourth of South Carolina, in the Pee Dee region. Of the electricity generated by CP&L, 47% comes from nuclear fuel, 40% from internal combustion or turbine, and 12% from coal.

Lockhart Power is the smallest of the investor-owned utilities in our state. It serves just over 5,000 customers, primarily in Union County. All of the electricity generated by this utility comes from hydropower.

Santee Cooper: South Carolina's Public Utility
The South Carolina Public Service Authority, known as Santee Cooper, is the state's public utility. It was created in the 1930's to bring electricity to rural areas.

When it started, less than 3% of South Carolina's farms had electricity. One decade later, Santee Cooper was bringing electricity to 91% of the farms in the state.

In 1990, Santee Cooper produced some 13.6 billion kilowatt-hours of electricity for its one million customers. This makes Santee Cooper the fourth largest public power system in the country.

THE ELECTRIC COOPERATIVES

Much of Santee Cooper's electricity is distributed by rural electric cooperatives. These cooperatives are customer-owned, nonprofit utilities. Their mission is to bring electricity to remote areas at the lowest possible cost.

Today, cooperatives reach nearly one-third of the citizens of our state in both rural and urban areas. To reach customers in rural areas, the cooperatives have to use a lot of power lines. In fact, over 53,000 miles of wire are used to bring electricity to South Carolina's rural citizens.

SOUTH CAROLINA'S ELECTRIC CITIES

South Carolina also has 21 municipal electric utilities. These 21 "electric cities" provide electricity as a public service. Local governments purchase electricity at wholesale prices and then distribute the power to their customers at retail rates. The distribution system is owned by the city.

The municipal electric utilities are financed by bonds. Bonds are certificates of debt which are issued by the municipal government guaranteeing payment of the original investment plus interest by a specified future date.

HOW WE USE ELECTRICITY

The industrial sector uses most of the electricity produced in South Carolina. Almost half of the electricity generated goes to operate factories and mills. Most of South Carolina's industrial users of electricity are concentrated in the Piedmont counties of Greenville, Spartanburg and Anderson.

Nearly one-third of the energy produced in the state is used in private homes. Everything from the basic (refrigerators) to the frivolous (ice cream makers) runs on electricity.

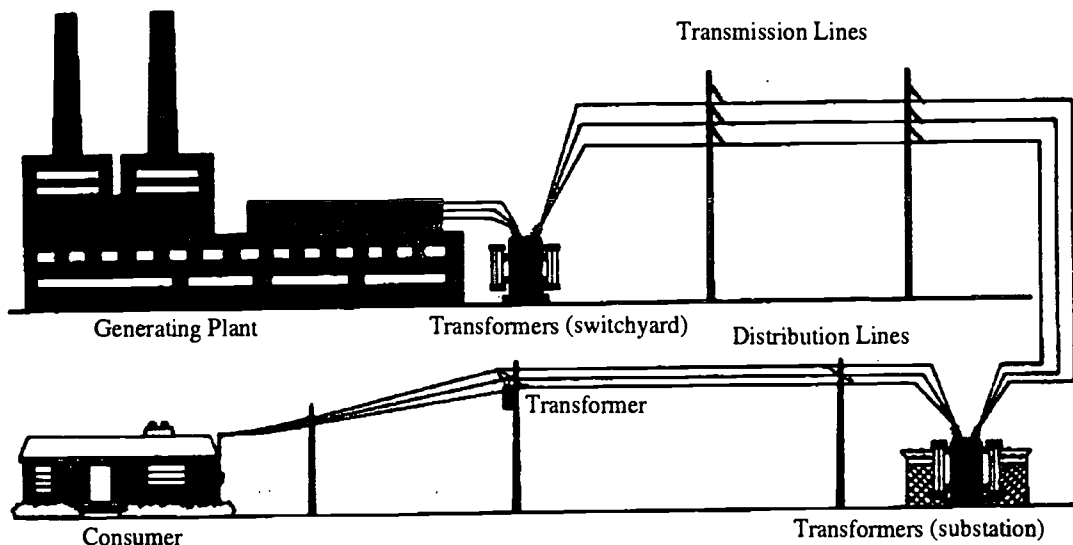
A little over one-fifth of South Carolina's electric energy goes to commercial customers. Again, the biggest users are in Greenville and Spartanburg counties. Charleston County is one of the biggest users of both commercial and residential electricity.

CONCLUSION

Electricity is an important part of South Carolina's energy past, present and future. Its utilities provide electricity to even the most rural areas. Modern technologies including the use of nuclear fuel and pumped-storage allow us to produce energy to meet the needs of all sectors of the South Carolina economy.

How Electric Energy is Transformed, Transmitted and Distributed

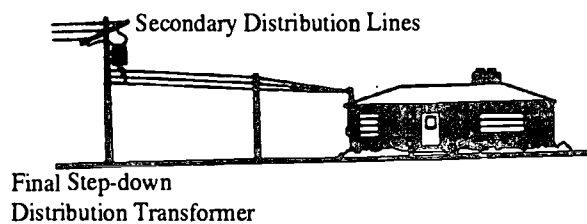
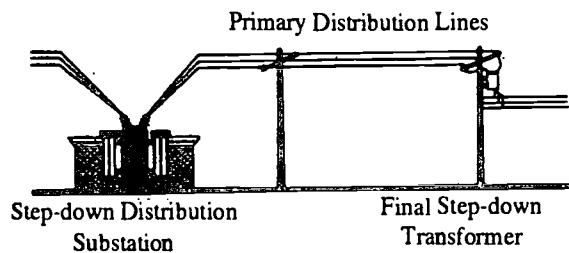
Use these illustrations to answer the question below.



South Carolina's power plants generated almost 80 billion kilowatt-hours of electricity in 1991. Power companies in the state maintain more than 150,000 miles of transmission and distribution lines.

Electricity, as it comes from a turbine generator, cannot be sent directly to your house. This is because electricity flows through a wire much like water flowing through a garden hose. Unless there is pressure pushing the water through the hose, it will not come out the other end. To get electricity through the wires to your home, it must be pushed under pressure. Voltage is the term that describes this pressure. Outside the power plant, **the switchyard has transformers that increase the voltage**. This increase in **voltage** gives the power the push it needs so that it can travel the long distances to reach homes and factories many miles away. The wires that carry this high voltage are called **transmission lines**.

When the electricity gets to your neighborhood, its voltage is too high to use in homes and factories. **At a substation, transformers reduce the voltage**. The electricity leaves the substation along wires called distribution lines. These are the lines along the streets in neighborhoods. Before the electricity comes into your house, the voltage is reduced one more time by a pole transformer.



True/False

- | | | |
|---|---|---|
| T | F | 1. Transformers are used to <i>increase</i> and <i>decrease</i> the voltage of electricity as it is sent from a power plant to your home. |
| T | F | 2. At substations the voltage of electricity is changed. |
| T | F | 3. Voltage is increased when power moves from transmission lines to distribution lines. |

Power In South Carolina

Use the charts, graphs, and illustrations in your handout to answer these questions about Power in South Carolina.

CIRCLE THE ANSWER

1. South Carolina depends on fossil fuels from
(a) coal mines in South Carolina (b) mines in other states (c) nuclear power plants.
2. Residents use
(a) 20% of the state's energy (b) 50% of the state's energy (c) 70% of the state's energy.
3. Fossil fuels make up
(a) two-thirds of the state's energy (b) one-third of the state's energy (c) half of the state's energy.
4. The Foster Wheeler plant generates power from
(a) nuclear fission (b) coal (c) municipal waste.

TRUE OR FALSE

5. _____ The residential sector in South Carolina uses more natural gas than electricity.
6. _____ The commercial sector in South Carolina uses more electricity than the residential sector..
7. _____ There are more hydroelectric plants in South Carolina than nuclear plants.
8. _____ The transportation sector is the single largest user of petroleum products.
9. _____ Transformers are used in various places in distributing power from the generation station to the consumer.

CHECK THE BOXES THAT CORRECTLY ANSWER THE QUESTIONS. YOU MAY CHECK MORE THAN ONE FOR EACH.

10. The fuel source for generating heat in the production of electricity can be

_____ Coal _____ Nuclear fission _____ Natural gas _____ Oil.

11. Check the kinds of problems caused by burning oil and coal.

_____ Air pollution _____ Water pollution

_____ Land destruction _____ Waste products

_____ Noise pollution

12. Match the fossil fuel with its most important use:

_____ coal	a. generation of electricity
_____ petroleum	b. heating houses and stores
_____ natural gas	c. transportation

Energy from the Sun

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 8

Focus: How much energy comes to us from the sun.

Subject: Science, Math

Materials: See list below

Teaching Time: One class period

Vocabulary: Solar energy, photovoltaic, active solar system, passive solar system

Learning Objectives

In this activity, students will:

- measure the amount of solar heat that comes from the sun
- describe ways this energy might be used to help reduce our dependence on traditional fossil fuels and nuclear power.

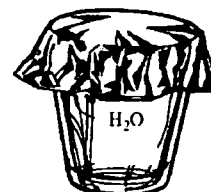
Materials

This activity works well for small group of students. For each student group performing the experiment, you'll need:

- two styrofoam cups
- two thermometers
- food coloring
- aluminum foil
- measuring cup
- metric ruler
- watch with second hand
- insulation materials (packing foam, shredded newspaper, etc.)
- cardboard box (should be the same height as the cups, trim the box if needed)
- cold water
- access to direct sunlight.

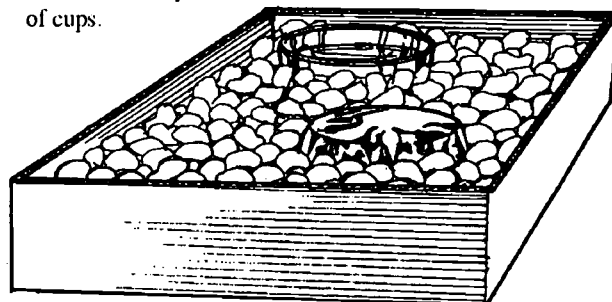


Add food colors to H₂O (water) in this cup to make the water as black as possible – this helps absorb sunlight.



Cover this cup with aluminum foil to reflect sunlight.

Top of box should be even with top of cups.



Pack insulation into all spaces around cups.

Background

excerpts from the *Energy FactBook, A Resource for South Carolina*

The sun is our most powerful energy resource. It heats our planet and nourishes the plants we eat. Without the sun, we could not exist.

The energy from the sun, or **solar energy**, is there for the taking. It is free and never runs out. If we could harness the sun's energy that falls on one square meter of the Earth's surface for one hour, we could light a city for one year. Also, the energy from the sun poses no environmental hazards.

The U.S. Department of Energy's National Renewable Energy Lab is testing a prototype integrated photovoltaic roofing system. By incorporating the panels in the roof, it eliminates the cost of installing panels.

source: *Solar Today*, August 1994

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DOWN TO EARTH

The Challenge of Tapping the Sun's Energy

With these many advantages, why aren't we using **solar energy** to meet all our energy needs? The answer is that tapping the sun's energy is not a straightforward process.

To effectively use the sun, it must be constantly available. Yet, even under ideal weather conditions, the sun does not shine 24 hours a day, 365 days a year. To be useful, sunlight must be collected, moved to where it is needed and stored. This is no easy challenge.

People have been using the sun's energy for thousands of years for space and water heating purposes. With the beginning of the space age, scientists were able to develop a system that converts sunlight into electricity. This is called a **photovoltaic** system.

In all solar power systems, the system must face the sun to work. We know that the sun moves across the sky during the day from east to west. To get the maximum amount of energy from the system, it should face due south, or only slightly east or west of south.

Active Solar Systems

Active solar systems use mechanical equipment such as pumps and fans to move energy around. There are two types of active systems, one for space heating and the other for water heating.

A house using active space heating will have to face south, with most of its windows on the south wall. This allows winter sunlight to enter the house, thereby heating the air inside.

When sunlight passes through glass into an enclosed space, the wavelength of the light changes. This new wavelength can not pass back through the glass, thereby entrapping it in the house. This is known as the greenhouse effect.

Equipment is used to collect heat and circulate it.

For solar water heating, a collector is mounted on the roof (facing south). A pump circulates water through copper pipes to heat it.

Passive Solar Systems

Passive solar systems do not use any mechanical equipment to move the energy. Tile, concrete, brick and water are used to absorb and store heat that is then released at night.

To be most effective, windows in a passive solar system must face south. In addition, insulation should be placed around the glass to reduce heat loss. Windows, doors, and walls need to be free of leaks so that trapped heat stays trapped.

Outside landscaping is another important part of passive solar systems. For example, evergreen trees that won't lose their leaves in winter can be planted on the north side of a home to provide winter protection. Trees that lose their leaves in winter can likewise be planted on the south side of a home to give it access to winter sunlight and to protect it from hot, summer sunshine.

Photovoltaic Solar Systems

Photovoltaic systems convert radiant energy from the sun into electricity. While photovoltaic technology has been around for 150 years, its actual development did not occur until 1954. It was first used in 1958 to provide electric power for US spacecraft and satellites.

The cost of producing electricity through photovoltaic technology has dropped significantly, from more than \$50 per **kilowatt** to less than 30 cents per kilowatt.

Today, photovoltaic systems are used to light road signs and bus shelters. Researchers developing electric cars are also using the technology.

Learning Procedure

1. Review with the class the background information on solar energy. **Ask:** How can we measure solar energy? (*Solar energy is measured as heat, or calories.*)

2. Have students work in small groups to perform this experiment to measure solar energy. Have each group record their results.

3. To set up the experiment, have students:

- Fill two foam cups with a measured amount of very cold water. (*Set a standard amount for students to use based on the size of the cups.*)
- To one of the cups of water, add several drops of food coloring to turn the water dark. (*Make the water as close to black as possible. Black absorbs sunlight.*)
- To the other cup of clear water, cover the top with a piece of aluminum foil. (This foil will reflect the sun.)
- Place the cups in the cardboard box. (*Be sure to trim the box if necessary so that the height is the same as the cups.*)
- Add insulation material around the cups. (*See illustration.*)
- Place the box in the sun for 10 minutes. Noon to 1 p.m. is usually the hottest time of the day.

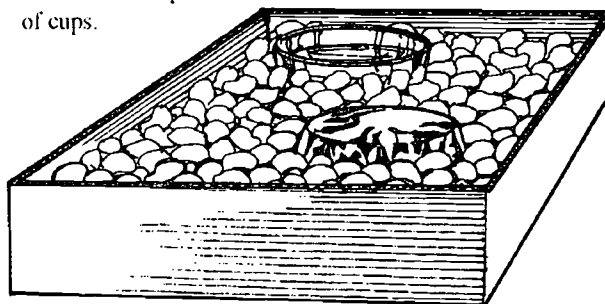


Add food colors to H₂O (water) in this cup to make the water as black as possible – this helps absorb sunlight.



Cover this cup with aluminum foil to reflect sunlight.

Top of box should be even with top of cups.



Pack insulation into all spaces around cups.

- After 10 minutes, stir the water in the cups with the thermometers and record the temperatures. (*Note: these measurements should be taken at the same time.*)
- Use these results to do the following calculation to find out how many calories, or the amount of solar heat, received on 1 square centimeter in one minute at your location.

Calculation:

$$\text{Area} = \frac{\pi d}{4} = \text{_____ square centimeters}$$

$$\text{Calories} = \frac{\text{ml of H}_2\text{O in 1 cup} \times \text{difference in temperature of both cups after being in the sun for 10 minutes}}{\text{Area (square centimeters) of water} \times 10}$$

The “calories” calculation is the same amount of solar heat received on 1 square centimeter in 1 minute at your location. Multiply x 10,000 to get results for 1 square meter.

Scientists have measured the amount of solar energy beyond our atmosphere at about 2.0 calories per square centimeter per minute. About 1.5 calories per square centimeter per minute reaches earth after passing through atmosphere. This is the Solar Constant.

4. After the experiment, have students consider how this solar energy might be applied to their everyday lives. What inventions or modifications to existing systems do they see as practical for using solar energy. For example, could passive solar energy be used effectively by schools, since most school buildings are not used at night? What about electric school buses? Have students explain their idea and how it would save nonrenewable energy resources.

Extension Activity

A great way for your students to see solar power in action is to participate in a **Junior Solar Sprint** competition. A model solar car competition for middle school science students, Junior Solar Sprint offers students a hands-on experience with a photovoltaic system.

In this annual competition, 6th, 7th and 8th grade students design, build and race model cars powered by solar energy.

Student teams are provided a kit which includes a motor and the solar panel. The rest of the car is made from any other materials at student description. Students are encouraged to use math and science principles together with their creativity in a fun, hands-on educational experience.

Participating schools and districts receive support throughout the process from engineers, parents, teachers and volunteers.

The goal of the Harmony Project, the coordinator for the Junior Solar Sprint, is to reach out statewide with this competition. The competition schedule begins in the fall (Nov. - Dec.) with the selection of host sites, volunteers, schools, and youth groups, and wraps up in the summer (May - June) with the school and area races.

Junior Solar Sprint was created by Argonne National Laboratory. Major funding has been provided by the U.S. Department of Energy. For more information contact, The Harmony Project, P.O. Box 21655, Charleston, SC 29413, (803) 577 2103, or the State Energy Office, 1 800 851 8899.

Just Do It

Select solar powered calculators
and other solar powered items.
They save energy and reduce waste
and you never have to
replace batteries!

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Don't Waste Away, page 1

Language Arts, Art, Environmental Science

Solid waste communications

Students will:

- discuss solid waste issues
- discuss establishing sound environmental habits at an early age
- explore how messages are targeted to children
- create a book on environmental issues.

The Environment On-Line, page 5

Computer Science, Science, Social Studies

Using computers to access the latest information about the environment.

Students will:

- explore the information about the environment available through on-line networks.

My Bag, page 7

Science, Math, Language Arts

Students will:

- see the volume of trash generated by each person in South Carolina
- identify trash as recyclable, reusable, or repairable
- demonstrate the principle of reduction.

Packaging Alternatives I, page 9

Environmental Science, Home Economics, Basic Math

Creating an awareness of packaging alternatives

Students will:

- keep a record of the materials and packaging purchased in their households for one week
- classify the packaging purchased as recyclable, nonrecyclable and/or degradable
- calculate the percentage of recyclable, nonrecyclable, and degradable packaging purchased by their households
- use calculations to estimate the percentage recyclable, nonrecyclable, and degradable packaging purchased by larger groups (e.g. whole class, school, county)
- identify alternatives to nonrecyclable packaging.

Packaging Alternatives II, page 15

Environmental Science, Home Economics, Art

Creating an awareness of packaging alternatives

Students will:

- discuss product packaging and advertising
- create a package design and advertising campaign
- look at environmental choices in packaging.

Enviro-Shopping I, page 19

Environmental Science, Social Studies, Home Economics

Understanding how our buying decisions affect the amount of waste we produce.

Students will:

- see how their buying habits affect the amount of waste they produce
- discuss the merits and pitfalls of “green” labeling and labeling regulations
- investigate how environmental labeling works in other countries

Enviro-Shopping II, page 29

Environmental Science, Social Studies, Home Economics

Understanding how our buying decisions affect the amount of waste we produce.

Students will:

- create samples of “green” product and package designs and create labeling standards that they think would be effective.

Read All About It, page 33

English, Journalism, Environmental Science

How the media reports on environmental issues.

Students will:

- research how the media reports on various environmental issues
- conduct a search for various environmental topics in the news.

Drawing Opinions, page 35

English, Creative Writing, Art, Social Studies

Students will:

- discuss local solid waste issues
- explore how messages expressing an opinion can be communicated
- create editorial cartoon addressing environmental issues.

Buy Recycled?, page 39

Home Economics, Environmental Science, Social Studies

Students will:

- find the reasons people in a grocery store buy certain products
- determine the influence of packaging on consumer choices
- determine if consumers consider waste and recycling when making buying decisions.

Creative Conservation, page 45

English

Students will:

- define the term “waste” and describe four waste categories
- write poems to express their thoughts about the social issue of waste.

Lights, Camera, Action, page 47

English, Speech, Drama, Social Studies

Using television and promotional announcements to show that protecting the environment is desirable.

Students will:

- identify some of the influences, appeals, and techniques advertisers use to promote products
- see how these techniques are also useful in educating and persuading the public on environmental issues.

Where Does the Good Stuff Go?, page 53

Environmental Science, Social Studies, Home Economics

Throwaway Society

Students will:

- understand that there are options to trashing used goods
- list reuse of goods as an option to landfill disposal and recycling
- list agencies that collect, refurbish, and sell or distribute used items
- list benefits to individuals and society of reusing goods
- cite examples of how ancestors dealt with shortages of clothing, building materials and equipment.

Poetry for Solid Waste, page 57

English, Environmental Science

Students will:

- see how poetry can be used to communicate ideas and feelings about environmental issues
- write poetry related to recycling.

The End Of The Road, page 59

Drama, English, Art, Social Studies

Students will:

- write the script for a play, which they will also perform, to encourage consumers to recycle and to reuse.

The Business of Recycling, page 61

Social Studies, Economics, Environmental Science

Students will:

- research South Carolina's recycling markets
- consider ways to encourage recycling markets
- examine the economics of recycling from a business point of view.

How Times Have Changed, page 65

Social Studies, Environmental Science, History

Population and waste management

Students will:

- interview parents, grandparents or other adults regarding their past lifestyles
- compare the waste management impacts of past and present lifestyles.

What It Really Costs, page 69

Environmental Science, Physical Science, Math

How the generation of waste materials may often be attributed to lack of insight of life cycle cost.

Students will:

- determine the total cost of an item over its lifetime of expected use.

Thermodynamics, Litter and Resource Recovery, page 73

Math, Environmental Science

Students will:

- become familiar with the Second Law of Thermodynamics
- see a littered school ground and garbage that has been dumped together as disordered systems
- understand that some resource recovery processes are energy and time intensive methods of trying to bring order to the system.

Generating Methane from Waste, page 75

Environmental Science, Chemistry

Students will:

- understand the energy-producing potential of some solid wastes
- examine some systems of generating methane from waste
- construct a model methane generator.

Spreading the Word About Sludge, page 79

Social Studies, Science

How sewage sludge and manure can be applied to the land to reduce solid waste and return nutrients to the earth. Students will:

- determine the benefits and drawbacks of land application of sewage sludge
- gather information on quantities and methods of sludge disposal in their communities.

Microorganisms: Bacterial Recyclers, page 85

Biology, Environmental Science

How microorganisms recycle

Students will:

- relate the importance of healthy microorganisms to composting.

Classroom Compost, page 87

Biology, Ecology, Environmental Science, Earth Science

The benefits of composting.

Students will:

- identify the components of an active compost pile
- explain the composting process
- identify current and potential markets and uses for finished compost products
- describe the benefits of composting as a waste management technique.

Household Hazards, page 93

Environmental Science, Home Economics

Household hazardous substances

Students will:

- distinguish between a hazardous substance and a hazardous waste
- inventory and classify potentially hazardous household products
- estimate the amounts of hazardous substances in households in their community.

Trading Wastes, page 103

Social Studies, Environmental Science, Health

Hazardous waste reduction and recycling, hazardous waste management, reusing

Students will:

- understand how reducing and recycling hazardous wastes can be both economically and environmentally sound
- know what a waste exchange is.

From Cradle to Grave, page 113

Biology, Environmental Science, Social Studies

Hazardous waste management, decision making

Students will:

- learn that the heart of our national and state hazardous waste management program is “cradle-to-grave” tracking of hazardous waste
- understand how Treatment, Storage, and Disposal facilities (TSDs), help manage South Carolina’s hazardous waste.

A Little Can Mean A Lot, page 119

Science, Environmental Science

Hazardous waste generators, school hazardous wastes

Students will:

- distinguish between small quantity and large quantity hazardous waste generators
- list examples of small quantity hazardous waste generators
- categorize potentially hazardous wastes found at their school
- identify and explain three strategies small quantity generators can use to reduce the amount of hazardous waste they produce.

The Cost of Industrial Waste, page 127

Economics

Industrial waste and disposal

Students will:

- determine the costs and profits associated with different phases of the manufacturing process
- describe how industrial waste is created
- explain how industrial waste disposal costs can affect product costs.

What's In Those Barrels?, page 135

Government, Environmental Science, Speech/Debate

Regulating and monitoring hazardous wastes.

Students will:

- describe the major functions of governmental agencies that regulate or monitor hazardous substances
- explain acts of Congress concerning hazardous waste
- discuss the role of a public hearing in a democracy.

How Very Little It Must Be, page 141

Chemistry, Math, Environmental Science, Communication

Drinking water and ground water

Students will:

- working from data, gain experience calculating ppm and ppb
- understand how proportionally small a ppm and a ppb are
- understand that very little of some contaminants goes a long way.

Making Acid Rain, page 145

Environmental Science, Chemistry, Biology

Understanding acid rain.

Students will:

- learn that burning nonmetals produces oxides called acid anhydrides that, when combined with water, form acids. As gases, acid anhydrides may dissolve in rain to form acid rain
- understand the potential harm to the environment from acid rain
- see how scientific information is used in making decisions about waste management.

Making Landfill Models, page 151

Chemistry, Environmental Science, Math

Leachate and landfills

This lesson includes construction of a landfill model.

Students will:

- define waste and leachate
- describe a sanitary landfill in terms of its construction and function
- identify some common chemical and physical properties of leachate
- describe the effects of leachate on soil and groundwater.

Your Waste Is My Waste..., page 159

Music, Social Studies

Students will:

- create new words to old songs
- understand the folk music process
- hear how music can be used to promote environmentally sound actions by increasing public awareness of waste reduction and recycling issues.

Deciding What To Do, page 163

Social Studies, Government, Environmental Science, Drama

Examining the issues and the decision-making involved in siting waste disposal facilities.

Students will:

- see the complexity of managing solid waste.
- realize the wide range of perspectives and values involved in making decisions about solid waste.
- understand that there is no one “right” or “correct” answer to most of the serious problems facing our society.
- learn an interdisciplinary decision-making process through role playing.

The Road to Energy Recovery, page 177

Government, Environmental Science, Debate

Waste management, decision making

Students will:

- list some of the considerations needed to site a waste disposal facility
- explain the necessity for long-range waste management planning
- examine environmental and social problems associated with waste management.

Environmental Careers, page 189

Science

Students will:

- discover career opportunities in environmental management and protection
- identify trade magazines and professional publications as sources of career information
- develop skills in using libraries.

Plastics By the Number, page 193

Environmental Science

Students will:

- recognize the role of plastics in our society
- understand the plastics coding system
- understand why plastics must be separated for recycling.

Sea of Plastics, page 199

English, Environmental Science, Biology

Students will :

- identify pertinent information regarding the effects of plastic waste on wildlife
- determine individual actions which can help reduce the magnitude of the problem.

The Natural Resources Shuffle, page 211

Science, Language Arts, History, World Geography

Students will:

- identify natural resources in the materials we use every day
- see how natural resources are used by the things we buy and use
- see where the natural resources we use come from
- identify ways we can protect natural resources.

Running Out of Resources, page 219

Environmental Science, Geography, Math

Students will:

- review the raw materials used in the manufacture of products
- examine data regarding the geographic sources and life expectancies of nonrenewable resources
- describe how energy supplies can affect the manufacture of different products
- identify the United States as the prime consumer of nonrenewable resources
- describe the affects of increased consumption and population growth on depletion rates of nonrenewable resources.

Curbing Our Resource Appetite, page 227

Math

Students will:

- predict the different amounts of a natural resource that will be consumed if consumption increases at different rates
- graph predictions of natural resource consumption as a function of time
- describe the effects, benefits, and costs of different resource consumption rates
- identify ways to reduce the consumption rates of natural resources.

Deinking Paper, page 235

Science

Students will:

- recycle paper to see the by-products of the process
- understand that by-products of all manufacturing processes pose potential environmental concerns
- see how technology is changing paper recycling.

Why Oil & Water Don't Mix, page 243

Science (Biology), Chemistry, Auto Shop

Students will:

- learn why it is important to recycle used motor oil to prevent it from polluting.

Recycling Used Oil, page 247

Social Studies, Science, Math

Students will:

- examine used oil recycling
- define the benefits of used oil recycling to their community
- compute the potential energy savings from recycling used oil
- research the logistics of recycling used oil in their community.

Changing the Way You Change Your Oil, page 253

Driver's Training, Auto Shop, Graphic Arts

Students will:

- learn how to change the oil in a car with used oil recycling as part of the procedure.

Getting the Word Out About Used Oil, page 259

Language Arts, Social Studies

Students will:

- survey their community to determine the level of awareness of used oil recycling, measure perceptions or misperceptions of the used oil problem, determine the willingness of the survey group to recycle used oil
- create a local public information campaign to educate students and/or adults to the benefits of used oil recycling.

Slippin' Up On Used Oil, page 269

Social Studies, English, Drama

Students will:

- look at prevailing misconceptions about what to do with used oil
- examine options to trashing used oil.

What Is This Stuff?, page 273

Environmental Science, Biology

Students will:

- investigate six major pollutants
- list ways to reduce air pollution.

Who's In Charge Here, page 283

Science, Government, Social Studies

Students will:

- research the history of environmental regulations
- research environmental regulation agencies.

Chemicals In Ground Water, page 285

Science, Biology

Students will:

- see how nitrates move from land to water
- see how water/runoff and pollution can affect water quality.

Why Water Pollutes Easily, page 291

Science, Chemistry

Students will:

- examine the structure of water and causes of pollution
- review criteria for analyzing water
- see basics of how natural and manufactured filtering systems work.

Water Quality, page 295

Applied Biology

Students will:

- discuss water's ability to dissolve substances
- discuss government regulation of drinking water quality
- test water samples.

Transpiration, page 299

Biology

Students will:

- observe various leaf adaptations to conserve water
- observe stoma in both monocot and dicot leaves.

Sun Bathing, page 305

Science, Environmental Science

Students will:

- create a model solar water heater.

Nuclear Power In Our State, page 311

History, Social Studies, Science

Students will:

- explore the history of nuclear power in SC
- see how much of our electricity comes from nuclear power
- examine why some people are concerned about nuclear power.

Energy Conservation By Design, page 317

Environmental Science

Students will:

- examine how controlling solar radiation can improve energy efficiency
- discuss home design for energy efficiency
- create their own home design for energy conservation.

Don't Waste Away

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Solid waste, Communications

Subjects: Language Arts, Art, Environmental Science

Materials: Two books: *The Wartville Wizard*, by Don Madden; *The Lorax*, by Dr. Seuss; and the poem, *Sara Cynthia Sylvia Stout*, by Shel Silverstein (in the Resource section); *Solid Waste Fast Facts* handout, and *Solid Waste Poetry* samples included with this lesson. Optional: DHEC "Trashumentary" video available from SC DHEC.

Teaching Time: One class period, outside projects that may take several days to complete.

Vocabulary: Municipal solid waste



IT'S NEVER TOO EARLY TO ESTABLISH
SOUND ENVIRONMENTAL HABITS.

Learning Objectives

Students will:

- discuss solid waste issues
- discuss establishing sound environmental habits at an early age
- explore how messages are targeted to children
- create a book on environmental issues.

Background

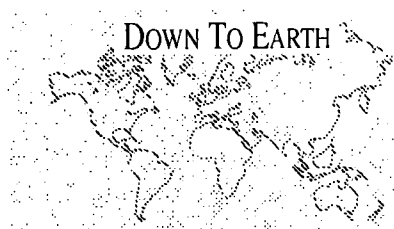
See the general introductory information in the Resource section for more information on solid waste in South Carolina. In the United States, our **municipal solid waste**, what we throw away, is:

- 37.6 percent paper
- 15.9 percent yard waste
- 6.7 percent food waste
- 6.6 percent glass
- 8.3 percent metals
- 9.3 percent plastic
- 15.6 percent other materials such as construction waste.

These figures are for trash coming from homes, businesses, and schools and going into municipal landfills and incinerators. (Except yards wastes that are now taken to special yard waste facilities.)

Based on these figures, each South Carolinian throws away an average of 5.6 pounds of municipal solid waste each day.

Solid waste issues and management practices are constantly changing. For example, South Carolina's 1991 Solid Waste Policy and Management Act banned yard waste from municipal landfills as of May 27, 1993. At the time, yard wastes made up about 20 percent of all wastes going to our landfills. Today this waste is no longer headed to the municipal landfill. Instead yard waste either goes to a construction and demolition debris landfill, that is a landfill strictly set aside for construction and



Industrial emissions blowing in from China have caused severe acid rain throughout Japan. Scientists found acidity in snow almost equal to that in orange juice.

Source: 1993 Earth Journal 9-12
PAGE
1

demolition debris and organic materials such as yard wastes, or it may be composted, as it is in Columbia and many other communities.

The Act also required scales at landfills to weigh the garbage. Based on these new local numbers, each South Carolinian throws away an average of 5.6 pounds of municipal solid waste each day. Earlier numbers showed volumes of waste as high as 6.6 pounds per person per day and as low as 4.5 pounds per person per day.

Although these figures will probably keep changing, the fact remains that solid waste is a serious matter. People can make a tremendous in the amount of trash created. The earlier sound environmental habits are established, the greater the long-term impact. Habits should include recycling, reusing, and source reduction. All children should be taught an appreciation for our environment.

Learning Procedure

1. Share the Background section of this lesson and Resource section materials with students.

2. Have students read *The Wartville Wizard*, *The Lorax*, and *Sara Cynthia Sylvia Stout*. (A poem found in the solid waste portion of the Resource section.) Also you may ask students to watch an environmentally targeted children's television program such as *Captain Planet*, or video. The DHEC video "Trashumentary" targeted to middle and high school students may also be shown. (You may contact DHEC's Office of Solid Waste Reduction and Recycling at 1-800 SO-USE-IT to borrow books and videos from their library.)

3. Discuss the messages presented and how they were crafted to suit the age of the audience.

4. Share the *Solid Waste Fast Facts* provided with this lesson.

5. Have students use these facts, background and Resource materials, or similar information gathered independently, to create their own books for children on reducing solid waste. Make sure they

target a specific age group. Projects may be a book of poems, modified nursery rhymes, a comic book, fairy tale, short story, picture book, coloring book, etc. (See poem samples provided.) It may be helpful to provide an assortment of children's books for students to look at to generate ideas. You may assign this as a group project with three to four students per group or as an individual project. Students will need several days to complete this.

Solid Waste Poetry Samples

*Mary Mary quite contrary
How does her garbage grow?
With convenience stuff and trash that's junked
and no recyclables in a row.*

*Mary Mary smiling so
How does your trash grow small
By buying recycled when ever she can
and then recycling it all!*

— B. Haggard

*Jack and Jill went up the hill
To reduce, reuse and recycle.
They rinsed and smashed and recycled trash,
And bought recycled after.*

— B. Haggard

*Jack Be Nimble
Jack Be Quick
Jack Recycle the Trash you Pick.*

— B. Haggard



6. You may find it interesting to work with an art class for this, with these students providing art and illustrations. Share your finished books with a nearby elementary school.

Extension Activity

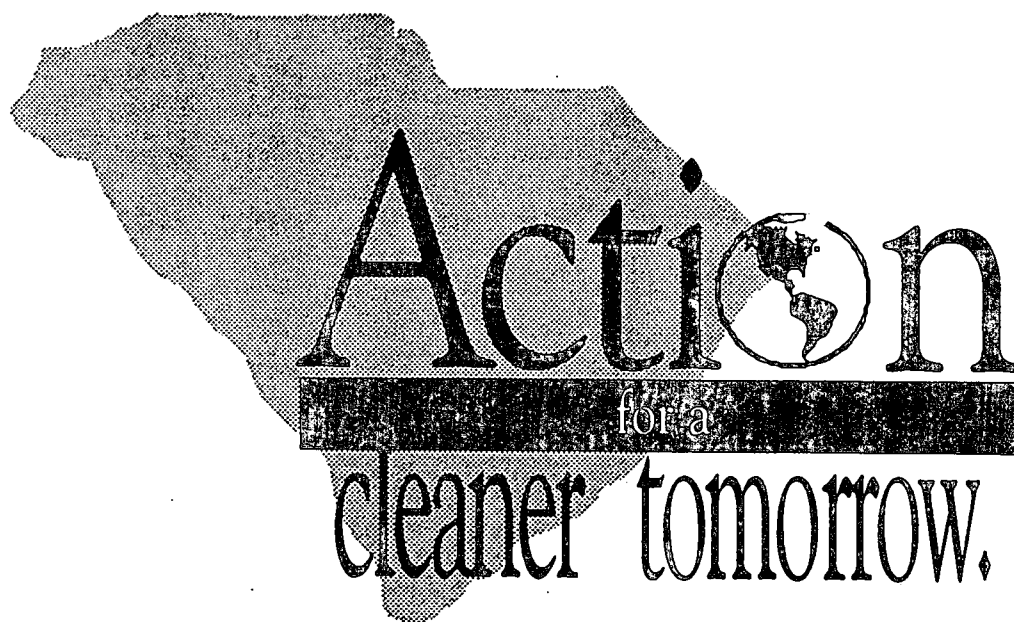
Have students research your local library for books on the environment suitable for their age group. Have students create an annotated bibliography and offer it to a nearby elementary school.



SOLID WASTE FAST FACTS

- The United States produces more garbage than any other country in the world.
- Each person in South Carolina is responsible for generating more than 5 pounds of trash each day.
- We produce enough trash to fill more than 63,000 garbage trucks each day.
- South Carolina's goals are to reduce its trash by 30 percent and to recycle 25 percent of all solid waste.
- Each minute, about 10,000 food cans are recycled in the United States.
- Americans throw away more than 700 million glass bottles each week.
- More than 25 billion polystyrene cups are thrown away each year. If all of these cups were placed in a line, the line would be long enough to circle the Earth 436 times.
- For each ton of paper that is recycled, 24,000 gallons of water are saved.
- For each ton of paper that is recycled, 17 pulp wood trees are saved from being cut down.
- Every hour we throw away 2.5 million plastic bottles.
- Each year, Americans throw away:
 - enough office paper to build a 12-foot high wall of paper from New York to Los Angeles
 - enough plastic soda bottles to circle the Earth four times.
- Recycling one six-pack of aluminum cans saves enough electricity to:
 - watch television for 28 hours
 - light a 100 watt light bulb for 57 hours
 - take three showers.
- “Think globally, act locally” is a phrase that points to the idea that each person can make a difference in reducing waste.
- Packaging accounts for a big portion of our garbage and up to 70 percent of packaging is suitable for recycling.

Source: A variety of environmental publications, including *The Recycler's Handbook*, by the EarthWorks Group.



A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

The Environment On-Line

9.3R.15.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Using computers to access the latest information about the environment

Subjects: Computer Science, Science, Social Studies

Materials: Computers, modems, and software for access

Teaching Time: Ongoing

Vocabulary: on-line networks, database

Learning Procedure

1. Review with the class basic information about on-line services and the information available.
2. Develop a project to access current information about the environment on-line. (*Note: The fees for using these services vary. Your parent organization may be interested in funding your project.*)

Learning Objective

Students will:

- explore the information about the environment available through on-line networks.

Background

– excerpted from *1994 Environmental Almanac*
Every day, environmental business is conducted on-line. Networks such as EcoNet and the National Geographic Society's KidsNet (via America OnLine) provide resources. Students gain access to learning programs and databases, and can even have contact with experts on the environment.

An example of how these databases can help students learn comes from a teacher who used a computer and modem to create a unique approach to teaching her fourth-grade students about earthquakes. Each day, the class dialed the U.S. Geological Survey for information on earthquakes that had happened in the last 24 hours. The students marked the locations on a map with pins. It did not take long for the children to map out the major fault lines along which most earthquakes occur.

BEST PICKS FOR GREEN ON-LINE SERVICES

CompuServe (CIS) - Environmentalists can get access to several forums – Earth, Outdoor, Humane Society, Gardening, Science and Math Education, and Safetynet. The Earth Forum has sections on climate, water, recycling, computers, and green business, among others.
1 (800) 848-8199.

America Online (AOL) - This service provides services including the Environmental Forum. Ted Turner's Network Earth is also available.
1 (800) 522-6364. This service also provides access to news and events for members of the Society of Environmental Journalists.
1 (215) 247-9710.

EcoNet - Members share information and access directories of environmental information including the National Wildlife Federation's Conservation Directory. 1 (415) 442-0220.

GreenDisk - This paperless journal on the environment provides monthly updates on environmental news, publications, videos, TV programs, newsletters, conferences, press releases, and much more. Six issues a year cost \$35 either downloaded from Internet or mailed to you on a disk. Contact EcoNet for information
1 (415) 442-0220.

DOWN TO EARTH



E-Law, an international electronic network capable of moving legal public-interest information around the world quickly, links attorneys representing citizen groups in 25 countries including the former Soviet Union, Chile, and New Zealand.

Source: *1994 Environmental Almanac*

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Get Your Information First & Fast!

DHEC's Office of Solid Waste Reduction and Recycling has access to these on-line information sources.

The Office is able to provide limited research of these environmental sources and can be reached by calling 1-800 SO-USE-IT.



SWICH: Solid Waste Information Clearinghouse

Contents: On-line library, updates of federal and state waste legislation, expert contacts, recycling markets, conference and meetings calendar.



RecycleLine

Contents: recycled products guide, recycling markets, commodity prices, events calendar, equipment and services data bank.



National Materials Exchange Network

Contents: industrial waste exchanges from across the United States. Includes materials wanted and materials available listings for solid waste, industrial by-products, hazardous waste and damaged or obsolete materials.



PPIC: Pollution Prevention Information Clearinghouse

Sponsored by the U.S. Environmental Protection Agency

Contents: technical information related to pollution prevention, experts list, federal and state program summaries.



South Carolina State Library System

Contents: able to search books, state publications and federal documents held at the State Library.



Journal Index

Contents: in-house index of solid waste and pollution prevention journals such as *American City & County*, *BioCycle*, *Resource Recycling*, *Waste Age*, and *Municipal Solid Waste Management*.

My Bag

9.3R.16.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 - 12

Focus: Recycling, Volume of waste

Subjects: Environmental Science

Materials: 5.6 lbs. of clean, selected trash (See note under Learning Procedure.), four or more clean plastic or paper bags, scale (kitchen or bath)

Teaching Time: 30 - 45 minutes

Vocabulary: Recycling, trash, reduce, reuse,

Learning Objective

Students will:

- identify trash as recyclable, reusable, or repairable
- demonstrate the principle of reduction
- visualize the volume of trash generated by each person in South Carolina each day.

Background

Each person in South Carolina (including students) generates about 5.6 pounds of household trash each day.

South Carolina's goal is to reduce solid waste going to our landfills and incinerators by 30 percent and to recycle 25 percent of our waste.

Through recycling or reusing, much of this 5.6 pounds of trash can be removed from the waste stream and not disposed in our landfills or incinerators. In this activity, students look into a typical bag of household trash and decide which items can be recycled, reused, or repaired, and which ones must be thrown away. For more information on the makeup of South Carolina's waste stream, see the Resource section.



Learning Procedures

NOTE: Before beginning this activity, it is important to know what is recyclable in your area. Check with your County Solid Waste Coordinator or call S.C. DHEC at 1-800-768-7348.

The trash in your bag should be representative of everyday household trash. Include items that can be recycled, reused, and/or repaired, and some things that can only go to the landfill (shiny potato chip bags, disposable diapers, some packaging.) For sanitary reasons, do not include perishable kitchen waste (orange peels are ok.) Be careful to stick to the 5.6 pound weight limit. Try to fill your trash bag with items that your students would use such as fast food wrappers, CD packages, soda cans, snack food packages, old clothes, cosmetic bottles etc.

DOWN TO EARTH



In 1991, more than 16,000 of the 31,000 grocery stores in the United States collected plastic bags for recycling.

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1. Show the students the bag of **trash** you have prepared and ask them to **estimate** its weight. Ask students to estimate from just looking at the bag and then from holding it. Weigh the bag. If using a bath scale, show students how to weigh the person with the trash bag, weigh the person without the trash bag, and subtract to obtain the weight of the trash bag. Your answer should be very close to 5.6 pounds.

Tell students this is how much trash each one of us generates every day. Remind them this figure includes trash from all of their meals, classroom waste, etc. However, it *does not include* any of the waste from business and industry. If included, each person's share of the total amount of waste generated in South Carolina each day would increase to 8.5 pounds.

2. Make cards marked: recycle, reuse, repair, landfill/incinerator. Optional: add a bag for "reject" – this would be used for items that students decide they would not purchase. For example, some single serve or convenience items might be rejected. Tape these cards onto the bags. Discuss what these words mean. Discuss with the class what is recyclable in your community, and how materials are prepared for recycling.

3. Dump the contents of the bag on the floor. Have the students point out several items and tell why they think they were purchased. Now that the items are trash, were they worth buying the product in the first place? Remind students that we can reduce the amount of trash we throw out by only buying what we really need, and buying products that are designed to last.

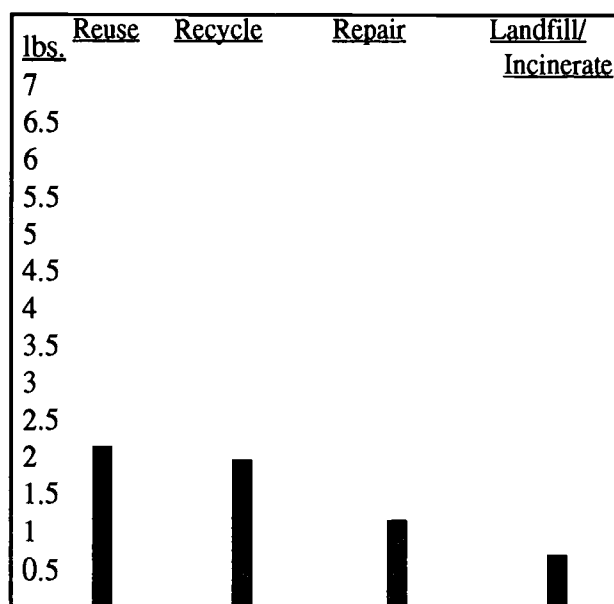
4. Have students divide the contents of the trash bag into the proper categories — recycle, reuse repair, and landfill/incinerate, *optional* reject. You may do this as a timed relay race. Have several students line up by the trash pile and give them two minutes to sort and categorize waste. This shows students how quickly these decisions are usually made.

5. After classifying, reweigh the items in the landfill category and discuss how much trash was saved from the landfill/incinerator. **Ask:** If everyone participated in recycling, how would this affect the amount of trash going to landfills and/or incinerators?

Extension Activities

1. Have each student (and teacher, too) tie a plastic bag to their waist. Each student is to place in the bag all class waste, clean and dry lunch waste, and any other waste each individual is responsible for generating. Compare the amounts at the end of the day. You could try this both before and after this lesson to demonstrate how the students' habits may change.

2. As a math exercise, create a chart graphing the weight of the bags after the 5.6 pounds of trash has been sorted into recycle, repair, reuse, landfill/incinerate, and reject.



Note: Your results may vary depending on the type of trash you select and what is recyclable in your community. There are no right or wrong answers.

Packaging Alternatives I

9.3R.1.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Creating an awareness of packaging alternatives

Subjects: Environmental Science, Home Economics, Basic Math (percentage calculations)

Materials: Samples of recyclable, nonrecyclable, and degradable packaging; *Our Waste Stream* transparency, *Weekly Household Purchase Record* and *About Solid Waste & Packaging* (one per student)

Teaching Time: Two class periods one week apart plus home assignment

Vocabulary: recyclable, nonrecyclable, degradable, compost pile, reuse

The key to successful packaging recycling is knowing the materials that are recyclable in your area, choosing these items, *and then* actually recycling them.

Learning Objective

Students will:

- observe and keep a record of the materials and packaging purchased in their households for one week
- classify the packaging purchased as recyclable, nonrecyclable, and/or degradable/compostable
- calculate the percentage of recyclable, nonrecyclable, and degradable/compostable packaging purchased by their households
- use calculations to estimate the percentage recyclable, nonrecyclable, and degradable/compostable packaging purchased by larger groups (e.g. whole class, school, county)
- identify alternatives to nonrecyclable packaging.



Learning Procedure

1. Project the *Our Waste Stream* transparency and review the relative amounts of each type of material in South Carolina's waste stream. Discuss how packaging contributes to this waste. Define and discuss the terms "reusable," "recyclable," "nonrecyclable," and "degradable/compostable."



Germany's Green Dot recycling program is estimated to cost each resident of Germany 30 deutsche marks (\$18.42) a year. These fees are passed to consumers through higher prices.

Source: 1994 Environmental Almanac

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About Solid Waste & Packaging

Each person in the United States generates about 660 pounds of packaging per year through regular buying and using habits. In South Carolina, packaging waste accounts for a



significant portion of the volume in our landfills. The South Carolina Solid Waste Policy and Management Act of 1991 sets a goal that, by 1997, the volume of solid waste will be reduced by 30 percent. To achieve this, we should take a look at the products we buy and the packaging waste bought and thrown away.

To reduce the negative environmental impacts associated with the disposal of packaging waste, consumers need to be aware of their packaging choices. For example, many consumers are not aware that **more than 70 percent of the packaging they discard is recyclable and could be used again to make new items.**

Recycling packaging saves energy and resources.

Recyclable packaging materials include most forms of paper, wood, steel, aluminum, and glass, and some forms of plastic like PET (polyethylene terephthalate) soft drink bottles and HDPE (high-density polyethylene) milk, water, juice, and detergent containers. Other forms of packaging, such as wax-coated paper containers are often **nonrecyclable** and, if possible, should be avoided.

The key to successful package recycling is knowing what is recyclable in your area.

In addition to purchasing recyclable packaging, consumers can also help to reduce the negative environmental impacts of packaging waste by purchasing degradable packaging. **Degradable** packaging materials can be decomposed by bacteria and fungi (biodegradable) or broken down by chemical reactions initiated by light (photodegradable). Degradable packaging materials include paper and wood. *(NOTE: The issue of degradability is controversial. Consider making an assignment to review recent literature on the topic to share with the class.)*

In looking at packaging that is degradable, it is important to remember that these items *do not* degrade in a landfill, and would need to be handled in a system for this, such as a **compost pile**. In regarding a material as degradable, students must evaluate how and where this process will take place.

Buying items that can be degraded in a compost pile is only effective if there is a compost pile available and if the action is taken to get the item there. As it is with recycling, an item is only considered degradable if there is a system available to process it. A recyclable or degradable item that ends up in the trash and on to the landfill or incinerator has not achieved its purpose.

Perhaps the most effective method of reducing the quantity of waste entering the waste stream is reusing. **Reuse** means giving an item another life and not simply discarding it once its intended use is complete. For example, a plastic margarine tub can be cleaned and reused many times to store leftovers. Reuse means rethinking shopping habits.

The most basic functions of packaging are to contain, carry, protect, and dispense materials. Containment is an essential element to packaging. Without the ability to contain products, especially liquids, distribution is difficult. Imagine how a grocery store would sell milk or juice without it.

Packaging can also serve useful secondary functions, preserving freshness and safeguarding against contamination, tampering and/or theft.

As competition for consumer attention in the retail market has grown, manufacturers have become increasingly dependent on packaging as a selling tool. The ability to display, motivate, promote, and communicate has been explored to the point that they have become prime purposes of packaging. As a result, much of today's packaging is not essential.

Packaging waste is placing heavy burdens on our nation's waste disposal systems. A large portion of used packaging is also discarded as litter on roadsides and beaches and in cities and parks.

To minimize the environmental impacts associated with packaging, consumers need to make informed choices. For example, reducing the packaging used to "sell" products could greatly extend the capacity of our waste disposal systems and reduce the litter problem.

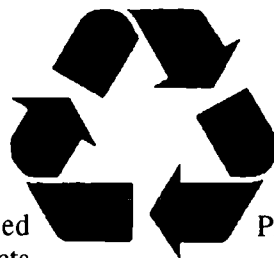
At the same time, a reduction in the amount of unnecessary packaging used would conserve energy and resources. By purchasing products with minimal packaging, and products packaged in reusable, recyclable and/or degradable/compostable materials,

we can all help to reduce the impacts of packaging waste.

Along with the strategy to recycle waste comes the responsibility to look for and buy products and packaging made from recycled materials.

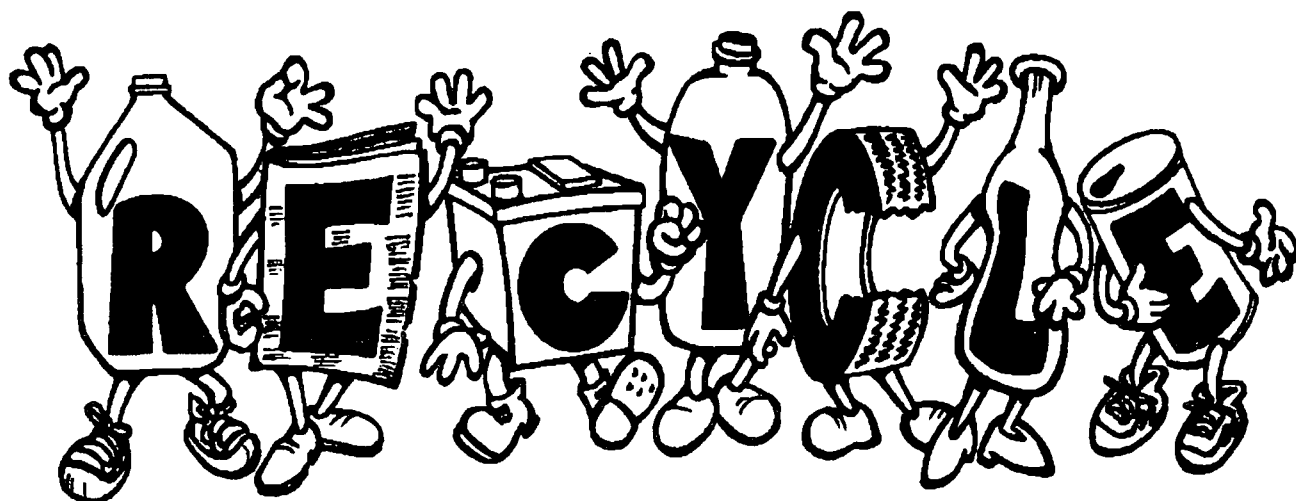
Buying recycled products is important. This is called closing the loop of recycling. Today more and more products are available made from recycled content. Items such as recycled notebook and computer paper, recycled plastic office products, and recycled paperboard cereal and food boxes are readily available.

Collect Recyclables



Buy Recycled
Content Products

Process Materials



Learning Procedures (Cont.)

2. Pass around samples of each type of packaging and discuss why it might have been chosen for the product. For example, some packaging is designed to help sell the product, to protect the product, or to offer a specific amount of the product, etc. Ask students to estimate what percentage of packaging waste is recyclable, what percentage is degradable or compostable, and what percentage is reusable. *Note: these numbers may overlap. An item may be classified several ways. There is no single right or wrong answer for this.*

3. Distribute copies of the *Weekly Household Purchase Record* (one per student) and instruct students to use this to keep a record of 20 household purchases during one week. For each item purchased, students will identify the type of packaging. For example, a 6-pack of soft drink cans would include aluminum (the cans) and plastic packaging (the ring holder for the cans) or the cardboard box. A box of cereal would include paper (the box) and plastic packaging (the box liner).

If students are not able to complete this assignment at home, ask them to list in class the last 20 products they recall using at home. Have students mentally walk through their day and list the packaged items they used. For example, their toothpaste may have involved packaging such as a box, the metal or plastic tube or pump, breakfast may have included cereal packaged in a paper box with a liner, milk may be in a waxed carton or plastic jug, etc.

Instruct students to classify each type of packaging on their lists as *R* (recyclable), *NR* (nonrecyclable), *D/C* (degradable/compostable) and/or *RU* (reusable). Also have students note if the packaging is made from recycled content *RC*. Students should make these classifications based upon what is actually possible in your community. For example, if your area recycles only certain types of plastic, such as PET #1 and HDPE #2, then only these two types should be classified as recyclable. At the end of one week or after lists are complete, have students complete Part 2 of their sheets and calculate the percentages of

packaging that are reusable, recyclable, nonrecyclable, degradable/compostable, and contained recycled content. *(If necessary, review the procedure for calculating percentages.)*

4. List each student's percentage results on the board and have students average results to estimate the overall percentage of reusable recyclable, nonrecyclable, and degradable/compostable packaging and packaging made with recycled content purchased by the class. Instruct students to record these values on Part 3 of their sheets.

5. Ask students to review their lists and identify alternative products their households could purchase to reduce the percentage of nonrecyclable packaging used. For example, if your community has glass recycling, consider whether ketchup or barbecue sauce should be purchased in recyclable glass bottles rather than in plastic containers that may not currently be recycled in your area.

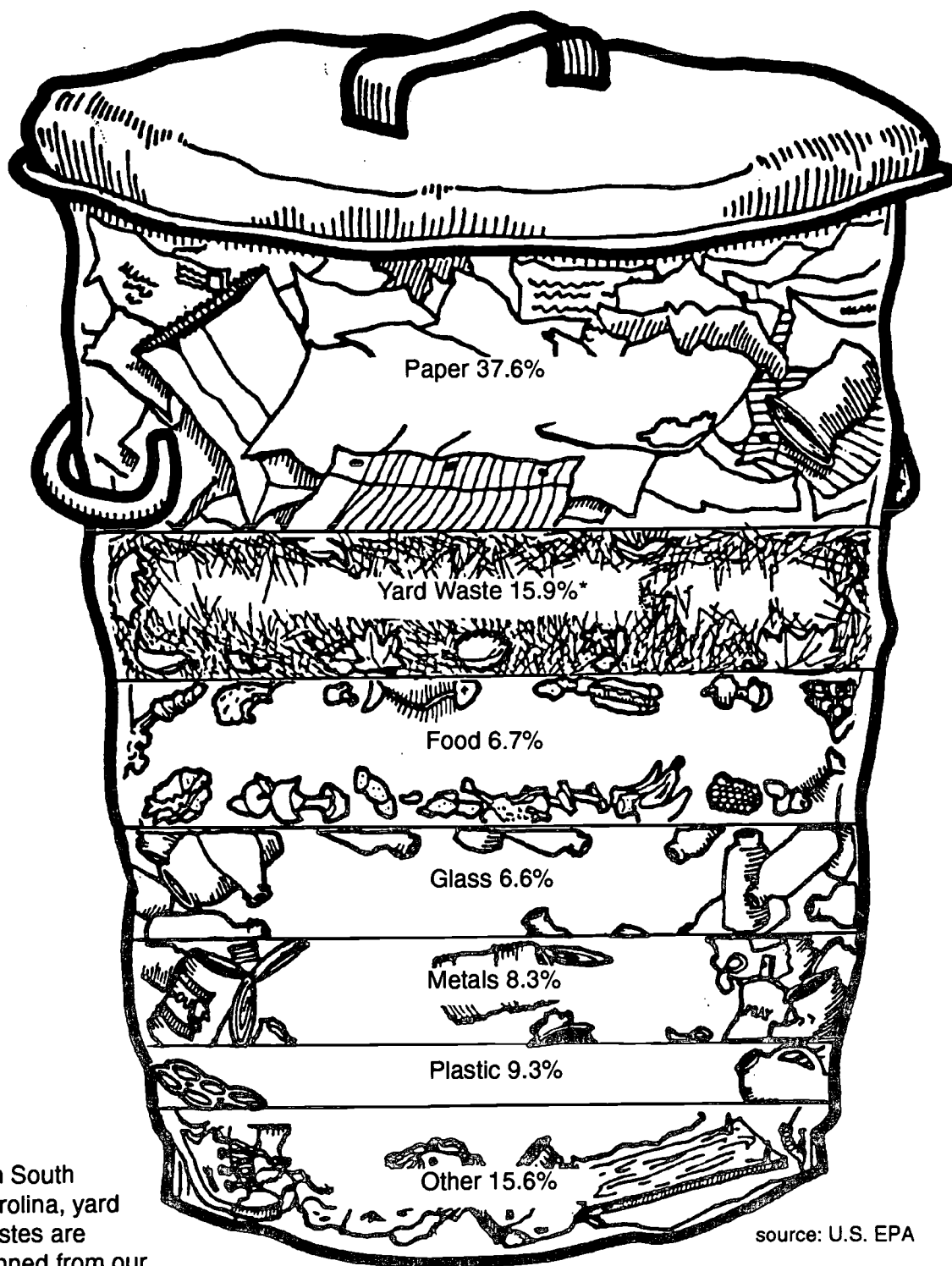
Extension Activities

1. Have students identify five common household items and describe reusable, recyclable, nonrecyclable, degradable/compostable, and recycled content forms of packaging for each item. For example, margarine may be packaged in a reusable plastic tub, a recyclable plastic tub, a nonrecyclable plastic tub or squeeze bottle, or a degradable or compostable cardboard container with a paper liner. *Note: most foods are not available in recycled content plastic packaging. This is currently a governmental requirement to protect public health. It has yet to be determined that plastics are recycled at high enough temperatures to kill all food bacteria.*

Just Do It

When your family shops for food, look for new ways to reduce the amount of packaging you purchase. If an item you like comes in wasteful packaging, write the company and request a change.

What's in Your Garbage Can?



WEEKLY HOUSEHOLD PURCHASE RECORD

Part 1

For each item listed, identify each different type of packaging used. For each type of packaging listed, use check marks to indicate whether it is recyclable (*R*), nonrecyclable (*NR*), degradable/compostable (*D/C*) and/or reusable(*RU*). Also identify if it is made from recycled content (*RC*).

[illegible]

Part 2

$$(\text{Total \# of each type of packaging} \div \text{Total \# of all types of packaging}) \times 100 = \% \text{ of each type of packaging}$$

_____ % recyclable packaging _____ % nonrecyclable packaging

_____ % degradable/compostable packaging _____ % reusable packaging

_____ % made from recycled content

Part 3

Estimated % of each type of packaging used by households of the whole class

_____ % recyclable packaging _____ % nonrecyclable packaging

_____ % degradable/compostable packaging _____ % reusable packaging

_____ % made from recycled content

Packaging Alternatives II

9.3R.1A.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Creating an awareness of packaging alternatives

Subjects: Environmental Science, Home Economics, Art

Materials: *Picking Packages* transparency, variety of art materials for students to use in creating packaging (see list below)

Teaching Time: One class period to introduce assignment, then time to complete project at home or school

Vocabulary: recyclable, nonrecyclable, reusable

Prerequisite: Packaging Alternatives I

Learning Objective

Students will:

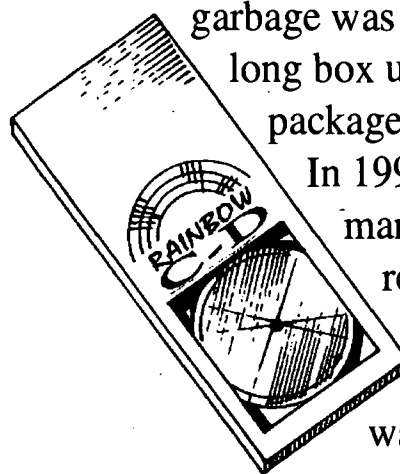
- discuss product packaging and advertising
- create a package design and advertising campaign
- look at environmental choices in packaging.

Background

Each person in the United States generates approximately 660 pounds of packaging waste per year just through regular buying and using habits.

In South Carolina, this packaging waste accounts for a significant portion of the volume of South Carolina's landfills and incinerators. The South Carolina Solid Waste Policy and Management Act of 1991 sets a goal that, by 1997, the volume of solid waste will be reduced by 30 percent. To help achieve this, South Carolinians should take a look at

An example of how awareness leads manufacturers to produce better packaging is the change in compact discs. In 1990, 20 million tons of CD-related garbage were tossed out. This garbage was caused by the long box used to package CDs.

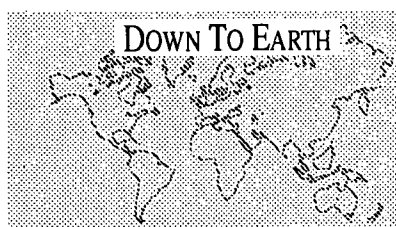


In 1991, manufacturers redesigned CD packages to reduce waste.

the products they buy and the packaging waste they buy and throw away.

To reduce the negative environmental impacts associated with the disposal of packaging waste, consumers need to be aware of their packaging choices. For example, many consumers are not aware that **more than 70 percent of the packaging they discard is recyclable and could be used again to make new items.**

Recycling packaging saves energy and resources.



The U.S. EPA's newest initiative is called "Cleaner, Cheaper, Smarter." Government teams will concentrate on regulations, pollution prevention, reporting, compliance, permitting, and environmental technology.

Source: *Business & Economic Review*, Oct/Dec 1994

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Learning Procedure

In this activity, students will compete in teams to design a product package with the environment in mind, and then sell the product.

1. Divide the class into groups. Select a product for students to use in creating a package and sales campaign. The product should be the same for each team such as a baseball bat, personal care item, tennis ball or other common item. If the package and advertising campaign work is to be done in class, collect the suitable materials for each team to use. These items may include:

- scissors
- glue
- tape
- construction paper
- markers
- rulers
- poster board
- potential packaging materials (aluminum foil, paper bags, plastic wrap, cardboard, etc.)

If students are going to complete projects at home, you may suggest the types of materials to use.

2. In a whole class discussion, ask students to describe what advertisers do (*create marketing plans and communications to help sell things*) and ask them to identify the different means of communications advertisers use to sell products (*television, radio, newspaper and magazine ads, billboards, contests, promotional flyers, packaging*). Make sure students realize that an advertiser's main goal is to "sell" a product. Briefly discuss the different "pitches" advertisers use to sell a product (*e.g. new and improved features, endorsements from famous people, status, convenience, keeping up with the Joneses, sex-appeal, better for the environment, cheaper*).

3. Set the stage for this activity by telling students to imagine they have just gotten a job as an advertising agent for a company that sells _____ (*the product you select*).

Explain that each group's assignment is to develop an ad campaign and packaging design to sell their

product. These campaigns should consider effective packaging to sell the product balanced by environmental concerns.

Instruct students to keep a record of reasons why they choose particular package designs and sales pitches. Explain that the ad campaign can consist of skits, poems, jingles, posters, or any other technique that could "sell" their product.

Briefly review the primary and secondary functions of packaging and describe the negative environmental impacts associated with packaging waste. Discuss the potential conflicts associated with packaging designed to sell a product versus packaging designed to have a low environmental impact. Ask students to brainstorm ways to design a package that sells, but doesn't create a lot of waste.

If this is an in-class assignment, distribute the product and other materials to each group. You may give students several class periods to complete their projects.

4. After groups have completed their projects, have each group present its ad campaign and package design to the rest of the class in a 10 minute presentation.

5. Assign each product package a number and display all package designs. Have students anonymously vote for the best package design and turn in their votes. Tally the scores and identify the first, second, and third place packages. Conduct a whole class discussion addressing the following questions:

- What made the winning package more appealing than the others?
- How much packaging was involved in the package? Was the packaging necessary? Why or why not?
- What influence does the packaging have on the quality of the product?
- Why was the product packaged?
- Who pays for the packaging?
- Who should pay for the disposal of packaging that isn't recyclable or reusable?

- Should the manufacturer of the product be concerned about disposal of the packaging?
- What impacts will manufacturing and disposing of the packaging have on the environment?
- If the manufacturer is primarily interested in selling the product, is it more important to package the item to sell than to package it to have low environmental impact?

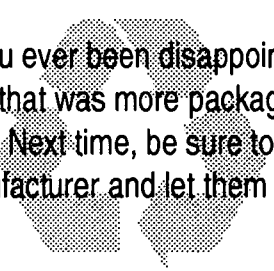
6. Ask students to identify packaging choices they can make to reduce environmental impacts. Show the *Picking Packages* transparency and rate the different types of packaging according to the disposal and recycling options in your area.

Extension Activity

Have students select several popular products and review the packaging. Can it be improved to create less waste? Do products contain any environmental claims that are not fully explained? Have students write letters to companies inquiring about packaging and requesting improvements.

Just Do It

Have you ever been disappointed by a product that was more packaging than product? Next time, be sure to write the manufacturer and let them know.



PICKING PACKAGES

When you go shopping, pick a product wrapped in the least amount of packaging as possible. Use this sheet as a guide when making your packaging decisions. A check (✓) in the ratings column means the packaging can be reused, recycled or composted; a zero (0) means the packaging is incinerated or landfilled; and a minus (-) means the packaging cannot be disposed of easily and should be avoided. **NOTE: You must research, know & understand what is and what is not recyclable in your area before you can accurately perform this exercise.**

<u>Kind of Package</u>	<u>Grocery Store Item</u>	<u>Rating</u>
No packaging or natural package	Fruits, nuts, vegetables	
Glass bottles	Beverages, oils, sauces	
Reusable items	Cookie and cracker tins, heavy duty plastic plates from microwave dinners, sturdy glass jars, plastic tubs	
Uncoated paper	Bags of candy, cookies, chips, and other snacks, sugar bags	
Uncoated cardboard	Cereal boxes, detergent boxes, sauce and mix boxes (without cellophane window)	
All-steel cans	Canned fruits and vegetables	
All-aluminum cans	Beverage containers	
Steel cans with aluminum tops	Some pull-top cans	
Waxed paper	Liners in cake boxes and other food boxes	
Cellophane	Windows in paper boxes, pasta bags	
Coated paper	Paper milk and juice cartons	
PVC (polyvinylchloride)	Some plastic bottles and plastic wraps	
HDPE (high density polyethylene) and PET (polyethylene terephthalate)	Plastic milk jugs, juice and soda bottles, some shampoo bottles	
Aluminum foil-based containers	Foil-lined boxes and bags	
Collapsible metal/plastic tubes	Toothpaste, hand cream, cake icing	
Metal and plastic pumps	Toothpaste pumps	
Aerosol cans	Toiletries, deodorants, hairsprays, pesticides, oil sprays	

Enviro-Shopping I

9.3R.10.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

Focus: Understanding how our buying decisions affect the amount of waste we produce

Subjects: Environmental Science, Social Studies, Economics

Materials: Handouts included with this lesson, sample products

Teaching Time: Several class periods

Vocabulary: Federal Trade Commission (FTC), life cycle analysis, cradle to grave, Green Seal



Two organizations, Green Seal and Scientific Certification System (SCS) are attempting to offer an analysis of products based upon their environmental impact, but some of their methods and the results are considered controversial.

Green Seal, begun by Earth Day co-founder Denis Hayes, has begun its label program. The first seals were awarded in January of 1993. Green Seal uses a modified **life cycle analysis** method in evaluating products. It looks at a product from the raw materials, manufacturing, transportation, and disposal cycles of its "life."

Green Seal's life cycle analysis methods are considered modified because the company's original full-blown research was scaled back due to costs. It can cost hundreds of thousands of dollars to research the environmental impacts of a product from **cradle to grave**, or from raw materials extraction through production, use, and disposal. The abbreviated analysis sets standards that a manufacturer must meet. To receive the Green Seal, bathroom tissues, for example, must be made from 100 percent recycled waste paper and at least 10 percent post-consumer paper (paper actually used and then recycled as opposed to recycled paper that may be floor scrap from the manufacturer); toxic

Learning Objective

Students will:


- see how their buying habits affect the amount of waste they produce
- discuss the merits and pitfalls of "green" labeling and labeling regulations
- investigate how environmental labeling works in other countries.

Background

(Information excerpted from "The Green Police," Garbage magazine, 1991, information in the August 1993 issue of State Recycling Laws Update newsletter, and the 1993 and 1994 Information Please Environmental Almanac.)

It's easy to be baffled by "earth-friendly" product claims. The truth is, for every product, no matter how valuable, we pay an environmental price.

Several organizations have gotten into the environmental labeling business and some companies are designing their own environmental logos for their products to support environmental claims.



A Roper Organization poll showed that consumers in the U.S. would be willing to pay an average 6.6 percent more for products that they think will not harm the environment.

Source: 1993 Environmental Almanac

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solvents can't be used to de-ink the waste paper, and there are limits on bleaching of the tissue; the final product can't contain dyes, inks, or perfumes, and must be packaged either in bulk or in 100 percent waste materials.

Criticism of Green Seal is that it will appear to convey blanket approval in a world where environmental impact depends to some extent on where you're sitting. "The diaper issue is a classic one," says Bob Hunt, a vice president at Franklin Associates, a firm that has done nearly 200 life cycle studies. Cotton diapers use lots of water, and disposables take up lots of landfill room. "In parts of California, they have 100 years left on the landfill, but they're out of water. In New England, they have plenty of water, but they're out of landfill space. How are you going to label that?"

Many environmentalists worry that consumers will stop thinking and just reach for a symbol, ignoring things like regional impact, source reduction, and over-consumption. Furthermore, the cost of testing, research and, in the case of Green Seal, a licensing fee, may mean that some small manufacturers won't be able to afford a seal, no matter how clean and green their products are. Many companies are staying out of the labeling controversy, waiting for the government to regulate labeling.

Scientific Certification Systems, founded in 1984 also has environmental claims certification, life-cycle assessment, a forest conservation program and food inspection and certification.

The U.S. Environmental Protection Agency (EPA) has looked at labeling but issued no guidelines.

The Federal Trade Commission (FTC) has issued guidelines. Green labeling is sometimes seen as a marketing issue rather than an environmental one, partly because companies misuse environmental claims like "biodegradable" and "earth friendly" in their ads. With the EPA and the Office of Consumer Affairs, the FTC has formed a task force to deal with environmental claims.

The American Society for Testing and Materials

also writes definitions that can become standards. They are working on definitions for degradability of plastics, among other issues.

Various states and regional groups are also coming forward with opinions and regulations.

Life Cycle Analysis: Science or Good PR?

With companies commissioning their own studies, the credibility of life cycle analysis (LCA) is questionable. According to one scientist, Reid Lifset, an associate director of Yale University's Project on Solid Waste and the Environment, "anyone can make a life cycle analysis produce results favorable to a sponsor through choice of modeling assumptions, data, and especially through careful framing of the questions that the study is meant to answer."

Another problem is that scientific conclusions are often interpreted by the company's PR firm. Pages of charts and data may be boiled down to produce a single sentence.

One example of this is the use in some studies of the term "environmental impact" to mean only the *weight* of pollutants and solid waste, not the affects of the toxicity of the pollutants.

The Society of Environmental Toxicology and Chemistry called upon scientists from several research firms and federal agencies to determine if a set of rules could be set for conducting a life cycle analysis and if a set of ethics could be decided upon for its use. They determined that it would take years to set these standards but agreed that three components should be standard in life cycle studies. These are:

- **Inventory** - The inventory is the skeleton of the study. It determines how in-depth the study will be. For example it will define if the study boundaries include the manufacture, distribution, use, and disposal of a product and its packaging, or if it considers the production of the raw materials. The inventory would also determine whether to consider such things as loss of habitat and biodiversity, groundwater contamination, generation 2 - 12 of global warming gases, and a host of other

considerations that are difficult if not impossible to quantify. Once you've decided what goes into the inventory, you do a mass balance: measure what's going into the system – renewable and nonrenewable raw materials, energy, process water, and so on. Then you measure the outputs – the product, the air, water, and ground pollutants, and solid waste at every stage from extraction of raw materials through transport, manufacturing, and disposal.

- **Impact** – Impact is difficult to determine.

One estimation of the relative harm of certain substances comes from the Occupational Safety and Health Administration (OSHA) that has a rating system for toxic chemicals.

- **Improvement** – This factor shows where and how pollutants could be reduced.

Is There Any Room For Common Sense?

According to Green Seal, common sense will give you an answer if you've got a little bit of the most important data. For example, since we know that making virgin paper requires tree cutting, heavy pulping, and chemical bleaching; and making recycled paper needs less pulping and bleaching, common sense says recycled paper is greener. And since paper and plastic bags pollute, a reusable shopping bag makes sense.

But most products and claims are much more complex.

Seals To Watch



Germany's
Blue Angel



European Community
Environmental Label



Canada's
Environmental
Choice



Nordic Council's
White Swan



Japan's
EcoMark

Although the United States has had difficulty in coming up with a single mark to rate environmental quality of its products, other countries have been experimenting with many designs and programs.

Germany's Blue Angel has been around since 1978. It appears on more than 3,200 products in 64 categories.

Since 1990, Canada has issued about 60 Environmental Choice seals in 18 product categories that emphasize recycling and reduced pollution. The standards, based on life cycle analysis, will be continually revised upward so that no more than 10 to 20 percent of the eligible products in a category qualify. The CEO of a company whose product is accepted must sign a statement that the company is in compliance with environmental regulations.

Japan's quasi-governmental program has awarded 850 EcoMark labels in 31 categories. The Japanese look at energy efficiency and minimal environmental impact during manufacture and do not use life cycle analysis.

The European Community, with trade open, is developing a system that countries can live with while the Nordic Council (Finland, Iceland, Norway, and Sweden) is also working on establishing a symbol.

Green Labeling Terms

used with permission from *State Recycling Laws Update 1993*, Raymond Communications

	General Terms	Term: Recycled	Term: Recyclable	Term: Compostable	Term: Degradable
FTC Guidelines	Suggests that companies avoid. Specify whether claims relate to product or to packaging.	Percentage of content. Pre- & post-consumer content. Show pre-consumer waste would go to landfill.	If only recycled in some states, must state few facilities.	Substantiate. Number of composting facilities listed.	Must state how product decomposes.
U.S. Attorney General Green Reports	Discourages vague terms. Distinguish product claims from package claims.	Pre- and post-consumer content stated. Only post-consumer considered recycled.	Must state location of item recycling.	Must state extent of availability of composting facilities.	Packaging disposed in landfills, should not use term.
California	Can require scientific substantiation of claim.	10% by weight of post-consumer recycled content.	Conveniently recycled in Calif. cities of 300,000 or more.	Does not address.	Must break down into non-toxic soil, water, CO ₂ within 1 yr. Must prove.
Rhode Island	Bans "environmentally friendly" and similar terms.	State pre- and post-consumer content percentages.	Materials on recyclable list or materials with 50% recycling rate.	Does not address.	Prohibited.
New York	General terms not addressed.	Sets specific percentage minimums that must be met for materials.	Programs available to 75% of population or available in city where claim made.	Does not address.	Does not address.
Indiana	Scientific substantiation.	10% recycled content, pre- or post-consumer.	Any material returned to economic mainstream.	Must decompose into soil-like material in less than 1 year.	Must break down in common disposal method in 1 year.
Other States	Other states do not address.		Vary.	Florida requires address.	Does not address.
Outlook	States do not want vague terms used.	Only when using post-consumer or diverting from landfill.	Laws yet to be decided.	Use only on an item fully degradable within 120 days.	Avoid use of term, further regulation likely.

SCIENCE FOR SALE

Have you heard the following put forth as scientific truth in product promotional claims: “Disposable diapers are better for the environment than cotton ones.” “Plastic grocery bags are as good as paper bags.” “Disposable plastic cups are better for the environment than disposable paper cups.” Well, then you have heard the results of a public relations firms’ interpretation of life cycle analysis.

According to Environmental Defense Fund scientist Richard Denison, “It really is the case these days that when you look at who sponsored a study, you don’t even have to open the study to find out what the conclusion was.”

Studying Plastic

The Council for Solid Waste Solutions, funded by the plastics industry, hired Franklin Associates to do two studies of plastic.

Franklin, which does a lot of these studies, performed what they call a Resource and Environmental Profile Analysis on two different categories of products: polystyrene vs. bleached paperboard fast-food containers and polyethylene vs. brown-paper grocery bags.

Franklin reported that polystyrene containers use 30 percent less energy (including the nonrenewable energy inherent in the plastic itself), produce 46 percent less atmospheric wastes, 42 percent less water wastes, and 29 percent more solid waste than paper board containers.

Near the front of the report was the following disclaimer: “No attempt has been made to determine the relative environmental effects of the pollutants such as fish kills or groundwater contamination, as there are no accurate data available.”

In other words, the “environmental impact that Franklin analyzed was the Btu’s that went into each product and the weight of the pollutants that came out.

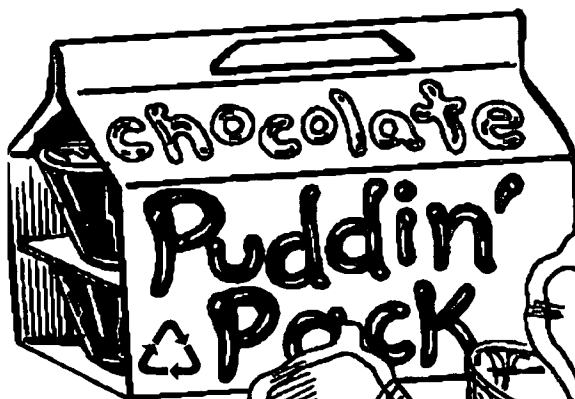
Nonetheless the Council on Solid Waste Solutions wrote letters to the media and politicians, boasting about plastic’s performance. Some quotes said, “the Council ... has released two comprehensive reports analyzing the *cradle-to-grave environmental impacts* of popular plastic products and their paper-based counterparts.”

The campaign worked. The *Los Angeles Times* and *Forbes* magazine were among the media that parroted the study as proof that McDonald’s had done the wrong thing when it traded foam containers for plastic-paper wrappers.

It is this sort of situation that’s motivating researchers to come to an agreement on how life cycle studies are conducted, and how it can be used. Otherwise, this new science may become just the newest, most expensive Madison Avenue tool.

Excerpted from Garbage magazine, 1991, this information is presented to get students thinking about the product claims they read and hear. It is not intended to focus on any particular product, such as diapers, plastic, or on any particular company such as McDonald’s.

Certainly, industry has a position in using commissioned research to substantiate product claims. Until there are established and accepted standards, these studies are what’s available to demonstrate product benefits.



SOME PRODUCTS ARE MORE PACKAGING THAN ANYTHING ELSE. WHILE SOME ELEMENTS OF PACKAGING MAY BE RECYCLABLE, MANY SINGLE-SERVE PRODUCTS CREATE MORE TRASH THAN THEY SHOULD.

if it is buried in a landfill? (No, conditions in a landfill do not allow much of anything to biodegrade. There is not sufficient air and sunlight for this process. Even food items and newspapers have been dug up from landfills after years and found in nearly unaltered condition.)

Ask: When you see a "chasing arrows" recycle symbol what does it mean? (The chasing arrows symbol does not have a standardized meaning. It may mean that the product or the package is all or partly recyclable or it may mean that some part of the contents were made from

Learning Procedure

1. Ask: Have you ever seen product packaging or advertising that includes references to that item's impact on the environment? Encourage students to think of as many types of items as they can. (You may want to bring in examples of products or have students bring these to class. Many products - from shampoos to cosmetics to anything with a recycle "chasing arrows" symbol - allude to environmental benefits.)

Ask: Why do companies use environmental claims on packaging? (Because of environmental awareness, many people will make changes in the brands they buy if they think one is "better for the earth." "Good for the environment" has become a major sales attribute that sells among many groups of people.)

Ask: What about claims that a product is earth-friendly? What does this mean? (It means nothing. In fact, the state of Rhode Island bans the use of this term and similarly vague claims on packaging.)

Ask: Can a "biodegradable" plastic trash bag degrade

recycled materials. In any case, the term "recyclable" is meaningless unless the person buying the product actually can and does recycle the material in his or her particular area. The Federal Trade Commission is issuing definitions for the terms recycled and recyclable but has not addressed the chasing arrows symbol as of Fall 1994.)

Ask: Would you change what you buy if one product did have environmental benefit over another? Would you expect to pay more for the product? What kind of proof would you need that the claim was true?

Explain to the class that these are the kinds of questions that are being asked as our country looks at the environmental claims being made by advertisers. On the positive side, many companies have changed the way they manufacture products to use less energy, to use fewer raw materials, to use more recycled materials, to create less waste, and to produce less toxic waste. For example, many items made of plastic are now made of much thinner plastic but perform just as well. The plastic soft drink bottle and the aluminum

can have been reengineered to use much thinner materials in the middle of the bottle. Companies have also changed the way they package products to reduce waste, to use recycled materials and to be recyclable.

Changes in products and technology are happening very quickly and it seems that new products making environmental claims are on our store shelves every day. Products claim they are "safe for the ozone," are "all natural," made from "all natural ingredients," made from recycled materials, are recyclable, are "environmentally safe," "contain no CFC's," and the list goes on.

2. Review with the class the Background material included with this lesson. For some classes you may want to summarize the materials and for others it may be suitable to copy the materials for home reading.

3. **Ask:** What role do you think the government of the United States should play in establishing standards for environmental product claims? What role do you think the South Carolina government should play in establishing standards for environmental product claims? How should these standards be enforced? Would you be willing to pay additional taxes to have the federal or state government involved in this? If not the government, then who should set standards?

Explain to the class that these are complex issues that are yet to unfold in our society. Some people believe that it is a responsibility of the government to set standards and enforce them while others feel that it would interfere with free enterprise and would end up slowing down the development and use of new technologies, similar to the criticism of the Federal Food and Drug Commission for holding up new medicines with too much red tape.

4. Bring in several products (of interest to students), such as two types of note books or back packs, one plastic and one canvas, with the packaging intact. Have the class discuss the life cycle analysis process for these. For example, discuss the packaging waste

and options to improve it, the materials and durability. How would students decide which one to buy? Which one is a better buy for the environment?

GREEN CONSUMERISM

Some companies go beyond making environmental claims about the products they make and sell. These companies incorporate their political positions into their marketing to reach a niche of people that they believe also hold their same beliefs. Companies are finding that their politics can be good for business. Companies like Ben & Jerry's Ice Cream and Benetton clothing chain are enjoying record sales as they link their political opinion to their marketing.

For example, for every cause the company supports, Ben & Jerry's has a product flavor. The company's Rainforest Crunch benefits rainforest preservation and Wild Maine Blueberry helps that state's blueberry-growing Passamaquoddy tribe.

Companies involved in this type of marketing make their opinions known in their advertising, on their packages, on aisle displays and on signs at cash registers, and other points of purchase. In fact, this type of marketing has come to be known as "point-of-purchase politics."

Some marketing experts estimate that teenagers spend \$79 billion every year. Most of this is spent on consumer goods. Topping the list of what teens buy with their own money are clothes and fast food.

Alice Tepper Marlin, director of the Council on Economic Priorities, and publisher of a pocket-sized paperback, *Shopping for a Better World*, that has sold 800,000 copies, says that you can "Turn your shopping cart into a vehicle for social change." The organization also launched a Corporate and Environmental Data Clearinghouse which has begun to issue reports on the environmental behavior of all 500 publicly held companies listed in Standard and Poor's.

The idea of providing consumers with information about corporations is catching on. *Asahi News Journal* in Japan recently ran a special report devoted to rating Japan's corporations.

source: 1993 *Earth Journal*

Read More About It

A WORD TO THE WISE:

BEWARE GREEN CLAIMS

- excerpted from *Home* magazine June 1993

When Earth Day 1990 reintroduced environmentalism to the masses, something profound happened. People from all over the industrialized world discovered that they were always interested in helping the earth. But most didn't know how to make a personal commitment aside from picketing in front of belching smokestacks or sending a check to save the baby seals. What they wanted was a way to help on an everyday basis.

Companies, eager to cash in on this newfound concern, began labeling products "earth friendly," "environmentally sensitive," or "biodegradable." In fact, in 1991, approximately 13 percent of products introduced in the U.S. made some environmental claim, compared to 0.5 percent some six years earlier, according to a study by SCS, a not-for-profit environmental group.

But this phase was only to last a year or so. A major lawsuit against Mobil Chemical Corporation, maker of Hefty-brand garbage bags, brought to consumer consciousness a torrent of questionable green advertising. The company had introduced a new line of garbage bags and labeled the packages "degradable." This message implied that the bag would "naturally" disappear in a landfill.

However, research by Professor William Rathje of the University of Arizona, an archaeologist often referred to as "garbologist," found that almost nothing degrades in a landfill. Because no air, light, or water penetrates these multistory behemoths, biodegradation here was chemically impossible. Indeed, Rathje found 30-year-old hot dogs and newspapers completely intact when he dug into dumps. After this revelation, a group of attorneys general from seven states sued Mobil to remove the claim. Mobil settled for \$175,000 and agreed not to make any more misleading marketing statements on the bags.

Fast on the heels of the Mobil suit, the attorneys general, led by Minnesota's Hubert Humphrey III, produced two reports that decried the use of a host of misleading green marketing terms. In the meantime, they sued and reached settlements with other companies that make products from disposable diapers to hair spray. Their targets weren't the products themselves, but claims like "ozone safe."

The "Hefty-bag" controversy had ushered in a new era of green marketing, one that called for more research, honesty, and accountability. And although the Mobil suit put many a green marketing effort on hold, comprehensive Federal laws regulating green claims were not forth-coming. The two Federal agencies most likely to regulate green claims, the Federal Trade Commission (FTC) and the Environmental Protection Agency (EPA), held a few hearings which resulted in the usual cautious optimism, yet did nothing to actually rein in the fast and loose world of green marketing.

The FTC took a small step forward in late July, announcing that it would issue guidelines for the use of terms the attorneys general had brought into question. The FTC guidelines, however, are strictly voluntary and don't carry any specific penalties if violated.

The House and Senate and a host of state governments have weighed in with various proposals and modest laws to regulate green claims, but few of the proposals seem to have much merit or bite.

Other countries, however, are years ahead when it comes to regulating environmental marketing claims. Germany, Canada, and Japan have initiated government-sponsored green seal programs that distinguish consumer products that are better for the environment.

Canada's closely watched "Environmental Choice" program is considering "life-cycle analysis" (LCA). LCA is a nascent science that attempts to discover how a product impacts the environment from the standpoints of raw materials, manufacturing, transportation, and disposal. This "cradle-to-grave"

approach will become the gauge to show how one product is kinder to the earth than another.

Consider, for example, the ongoing "plastic versus paper" controversy. A major argument: whether plastic or paper will disappear faster in a landfill. LCA proponents suggest that disposability is but one of several considerations. Others include: How much pollution is created by each manufacturing process? And, which material requires the least amount of nonrenewable resources and energy? Paper, made from a "renewable" resource such as fast-growth pulp trees, is expensive to recycle and doesn't degrade in landfills any better than plastic. By volume, paper is one of the principal landfill components. Conversely, polystyrene plastic, used in fast-food "clamshell" boxes, is recyclable, but doesn't degrade much, either. And polystyrene plastic consumes petroleum and produces toxins during manufacturing. The material to choose? Scientists can't come up with a straightforward answer, because no organization has measured how much energy, raw materials, pollution, and other waste are actual by-products of each process.

Although the U.S. government is studying the European, Japanese, and Canadian programs, it's unlikely that similar programs will be in place here anytime soon, owing to Congressional politics, budget constraints, and other priorities. For this reason, two private groups have emerged in the green labeling field. Green Seal, begun by Earth Day co-founder Denis Hayes (who has since left the program), and supported by major environmental groups, has just begun its labeling program. Like SCS, Green Seal also wants its symbol to become the de-facto standard for green labeling.

Norman Dean, president, Green Seal, says the group established its criteria after an exhaustive private and public comment period. Its first seals, after a delay of more than a year, were finally awarded in January of 1993. Tissue paper, refined engine oil, printing, and writing paper are expected to be the first products Green Seal evaluates.

Skeptical of the life-cycle-analysis approach, Dean cautions that "experts have concluded that formal LCA hasn't developed to the point that you can use it to recommend one product over another." Consequently, Green Seal has asked Underwriters Laboratory, the giant industrial testing concern, to verify claims.

Green Seal thus far has received the blessing of the Washington green lobby because the organization is guided by members of the leading environmental groups. Although business representatives are allowed to sit on the Green Seal board of directors, those associated with consumer products companies are not. Green Seal will review its own criteria every three years. The public will be encouraged to comment on them. An advisory committee of scientists and other experts will work with the group's "Environmental Standards Council" to draft final recommendations and monitor the program.

SCS, the other would-be arbiter of all green claims, is taking a different tack. Rather than setting standards for manufacturers to meet, SCS has focused its efforts on claims certification by inspecting factories and other aspects of manufacturing. The group has certified more than 400 products. For example, the group has determined that certain garbage bags contain recycled plastic, and that selected paper products are made from "post-consumer waste," stuff that's been thrown out. As the nonprofit branch of Scientific Certification Systems in Oakland, California, SCS has for years had a team of scientists checking for pesticide residue on produce.

SCS also is forming an alliance with industry groups, manufacturers, environmental engineers, and private institutions like the Good Housekeeping Institute, to test and certify environmental claims. The group recently teamed up with the Home Center Institute and the National Retail Hardware Association to independently review green labeling on a wide variety of products sold in some 15,000 stores across the country. Participation is voluntary, but stresses partnership in verifying green claims at both the manufacturing and retail levels. SCS has collaborated in a similar way with West Coast supermarket chains.

Ellen Hackney, spokesperson for the Home Center Institute and the National Retail Hardware Association, says the SCS program will "first concentrate on those manufacturers that already have put environmental claims on packaging." SCS, in cooperation with these same groups, will produce informational brochures that address health issues such as lead poisoning.

SCS also is working with the Home Depot and Fred Meyer retail chains to develop certification programs and environmental education information.

The SCS approach is similar to that employed by the Department of Agriculture. This agency provides research and information to farmers as well as inspecting and certifying meat and produce.

By working closely with retailers, SCS hopes ultimately to improve the environmental quality of merchandise and to provide standardized comparison shopping-guide labels for every certified product. Linda Brown, SCS spokesperson, says the company is developing an "Environmental Report Card" that will show the kind of toxins and environmentally unfriendly substances created in a product's manufacture. A can of paint with such a report card would tell how much carbon dioxide and smog-producing volatile organic compounds (VOCs) are released into the air when the paint is used. Although not full-scale LCA, the report card is a step toward the "nutritional style" labeling that consumers find most helpful. By this year, Brown hopes that report cards will be "on dozens of products."

"Consumers will have an opportunity to make decisions in a way they didn't have before," she says. "They won't have to take the word of someone else [on environmental claims]. I think this will be a precedent."

As for when the Federal government will regulate green claims, nobody is holding his or her breath. Julie Lynch, who monitors the green labeling arena for the EPA, says the agency is "in the process of finding out the utility of lifecycle analysis." On the EPA's view of

the third-party certification programs: "It's an experiment as far as we're concerned," she says.

Years will pass before any public or private program has enough research behind it to say conclusively whether one product is better than another in terms of total environmental impact. This will require years of study on subjects ranging from forest harvesting to recycling-process energy consumption.

by John K. Wasik

Enviro-Shopping II

9.3R.11.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

Focus: Understanding how our buying decisions affect the amount of waste we produce

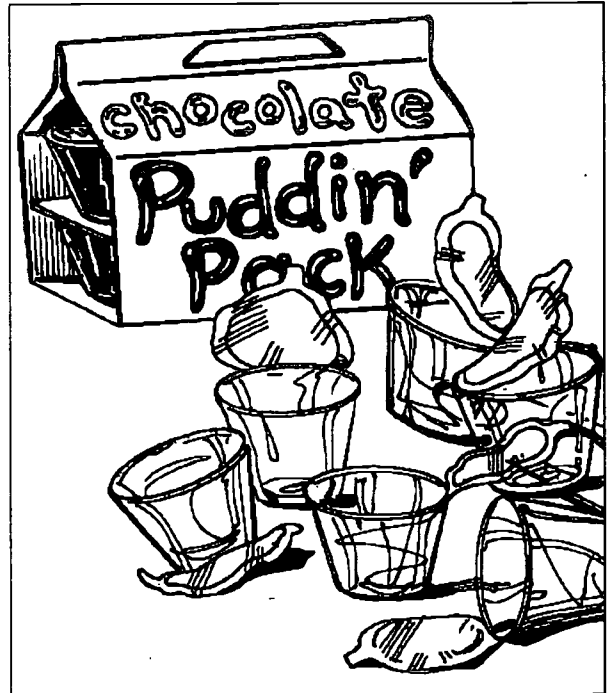
Subjects: Environmental Science, Social Studies, Home Economics

Materials: Handouts included with this lesson, sample products with packaging

Teaching Time: Several class periods

Vocabulary: life cycle analysis

Pre-requisite: Enviro-Shopping I



Learning Objective

Students will:

- create samples of “green” product and package designs and create labeling standards that they think would be effective.

Background

Please see Enviro-Shopping I for Background information for this lesson.

students evaluate their product and its potential environmental claims.

Learning Procedure


1. Tell the class that in this Enviro-Shopping activity, they are going to select a product and set the standards for environmental claims. They will also design a symbol that would let the public know that the product was indeed “better for the earth.”

You may wish to challenge the class to improve the worksheet by finding additional environmental elements to consider in evaluating their products.

2. Distribute the student product work sheets, *Environmental Testing and Claims*, or use an overhead projector and have students produce their own worksheets. If an overhead projector is not available, you may want to copy the worksheet on the board. The worksheet serves as a guide to help

Extension Activity

Have students complete the *Consumer Survey* included with this lesson.



It wasn't until shortly after 1800 that the world's population “cracked the 1 billion mark, and not until 1930 that it reached 2 billion. Now the world's population grows by a billion about every 12 years.”

Source: *The 1994 Information Please Environmental Almanac*

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Environmental Testing and Claims

Name and Type of Product _____

Does the product or product packaging make or imply any environmental claims? What are they? _____

Are these claims in any way qualified or substantiated? Are there references to any scientific studies or standards used?

Does the product or package have any environmental type symbols? If so, what do they represent? _____

If you were going to evaluate the product and give it an environmental seal of merit, consider the study framework suggested by the Society of Environmental Toxicology and Chemistry and outline the study for your product.

1. Inventory - How in-depth would the study need to be? Will you include manufacture, distribution, use, and disposal of the product and packaging, the renewable and nonrenewable raw materials used? If so what elements would be important? Would you need to consider byproducts of production, pollution, energy use? If so, what are they?

2. Impact - Does this product cause harm to the environment? In general, what is this harm and how would you rate it?

3. Improvement - Could pollutants be reduced? Could the resulting solid waste be reduced?

Do you think that your product currently merits any environmental seal or has any special environmental qualities that make it a superior product? _____

Do you think the product could be changed to merit a seal? How? _____

Do you think that these changes would cause an increase in the sales price for the product? If so, do you think the company that makes the product would be wise to change the product? Why? _____

Design your Environmental Seal of Merit and describe its standards.

A Consumer Survey

Grand Total of 38 or more means you are contributing your fair share to the solid waste problem. Think of ways you can improve your shopping!

Grand Total of 25 to 37 means you are doing some good things to reduce waste.

Grand Total 24 or less means you are a super shopper. Next time you shop take someone along and show them how you do it!

Do You ...	Never 3	Sometimes 2	Often 1
1. Consider whether you really need something before you purchase it?			
2. Think about what will happen to a product or package after you no longer need it?	3	2	1
3. Try to reuse things you already have instead of disposing of them and buying new things?	3	2	1
4. Consider what pollution and wastes were created in the manufacture of the things you buy?	3	2	1
5. Take advantage of the opportunities to recycle in your area, or advocate establishing recycling?	3	2	1
6. Purchase items with recycled content?	3	2	1
7. Shop at second-hand stores or garage sales?	3	2	1
8. Do you see "bargain" as a factor of quality and durability as well as price?	3	2	1
9. Donate old clothes and other items for further use?	3	2	1
10. Use reusable items instead of disposable products?	3	2	1
11. Refuse to buy products that contain too much waste packaging?	3	2	1
12. Use mugs or cups at work/school/parties rather than disposables?	3	2	1
13. Buy in bulk or buy concentrates that use smaller packages?	3	2	1
14. Use less toxic substitutes for cleaning and household maintenance?	3	2	1
15. Write to companies or governmental officials about your concern about the environment and wasteful products?	3	2	1
16. Read consumer articles to find out about the quality and durability of products you buy?	3	2	1

Total

Grand Total

245

Read All About It

9.3R.12.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: How the media reports on environmental issues

Subjects: English, Journalism, Environmental Science

Materials: Several current news stories or articles about the environment, *Searching the News* handout included with this lesson (optional)

Teaching Time: Partial class period to introduce then ongoing, plus student research assignment

Learning Objective

Students will:

- research how the media reports on various environmental issues
- conduct a search for environmental topics in the news.

Background

Read any daily newspaper or watch any of the major network and cable evening news programs and you're likely to see at least one feature on the environment. Many environmental news stories involve several issues including state and federal governmental regulations, technology, and business. What's going on in our environment is big news.

Learning Procedure

1. **Ask:** What was the last news story you heard or read about concerning the environment? (*List these on the board and have students recall as much information as they can about these stories.*) Share with the class the environmental news or articles that you found.


2. Assign students to keep a class bulletin board of environmental news they find in local newspapers

and magazines, and that they see on television news. News clips and articles may be original or copies. Written material should be properly documented with the name of the publication, title of article or story, the date, and page number. To document television news reports, have students write down the feature lead idea and a few details. They should also document the day, program, and network or cable channel.

Assign students to bring in several items for the bulletin board over a specified length of time. Every week, have students discuss what they think the top environmental news stories for the week were nationally and locally.

Extension Activities

1. As an ongoing project for the year, have the class summarize the important environmental news stories from their bulletin board into a regular column for the school newspaper.
2. Have the class complete the *Searching the News* handout assignment. You may group students in teams and use the squares similar to a bingo board challenging teams to complete all squares or any line.
3. Invite a representative from your local newspaper who covers environmental news to speak to the class on sources of information and issues.
4. Have students review their clips for a specific length of time and evaluate the content. How does the media report environmental news? What weight is given to scientists, activists, the government?



South Carolina recently made national environmental news when three companies in the state were fined a combined \$1.05 million for alleged hazardous waste violations.

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Searching The News

The media plays a tremendous role in keeping environmental issues in the forefront in our society. You can find articles that relate to the environment in nearly every special interest publication and in nearly every issue of the newspaper.

Over the next two weeks, search through newspapers and magazines to find each of the environmental news clips listed here.

Save your clips, or copies of clips, in a notebook. Number each one according to the corresponding number on the item below. Add the name of the publication, the date, and the page number.

1 A HEADLINE ABOUT GOOD ENVIRONMENTAL NEWS	2 THE PHRASE "ACCORDING TO THE EPA"	3 AN ENVIRONMENTAL COMIC STRIP	4 A NEWS WIRE STORY ABOUT THE ENVIRONMENT
5 A STORY ON SCIENCE OR TECHNOLOGY RELATING TO THE ENVIRONMENT	6 A STORY ON HEALTH EFFECTS OF POLLUTION	7 A NEWS ITEM ON RECYCLING	8 ENVIRONMENTAL HINTS IN AN ADVICE COLUMN
9 ARTICLE THAT INCLUDES REFERENCE TO SC'S DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL	10 AN ADVERTISEMENT THAT REFERS TO THE ENVIRONMENT	11 A PHOTO THAT REFERENCES THE ENVIRONMENT	12 A STORY ABOUT ENVIRONMENTAL LEGISLATION
13 A LETTER TO THE EDITOR THAT REFERENCES AN ENVIRONMENTAL ISSUE	14 AN EDITORIAL ABOUT AN ENVIRONMENTAL ISSUE	15 A HEADLINE THAT REFERENCES AIR OR WATER POLLUTION	16 A REVIEW OF AN ENVIRONMENTAL BOOK OR TELEVISION SHOW

Drawing Opinions

9.3R.13.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

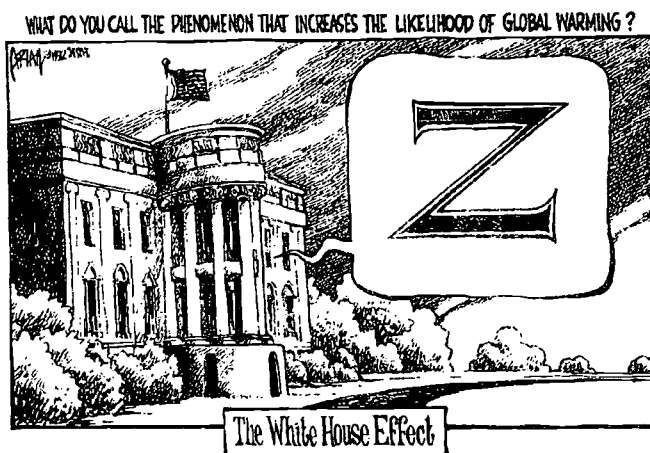
Focus: Communications

Subjects: English, Creative Writing, Art, Social Studies

Materials: A weeks' worth of editorial pages from your local newspaper, *Arial's Environmental Comments* (handout)

Teaching Time: One class period, outside projects

Vocabulary: Political cartoon, lampoon, editorial, broadsheet



Learning Objective

Students will:

- discuss solid waste issues
- explore how messages expressing an opinion can be communicated via the political cartoon
- create editorial cartoons addressing environmental issues.

Background

See the Resource section for more information on solid waste in South Carolina.

The **editorial** pages of newspapers across the country employ the quick wit of artists to state opinions on issues of the day. Satirical commentary is the stock in trade of the editorial cartoonist.

Editorial commentary through **political cartoons** has a rich and lengthy history. Advancements in printing technology in the 18th century made the woodcut illustration possible in newspapers called **broadsheets** that were plastered on walls for all to

read. Illustrations and woodcuts made information and commentary available for those many people who did not read.

The art of the political cartoon, however, didn't hit full stride until the late 19th century in America. It was political corruption and scandals such as Tammany Hall in New York that fueled the editorial cartoonists such as Thomas Nast's **lampooning** fires. Nast's work was so influential and widespread that convicted New York mayor, "Boss" Tweed escaped from prison, and was arrested in Spain after he was identified from a Nast political cartoon.

Editorial cartooning today remains a significant tool for expressing opinions on issues of the day. The successful editorial cartoonist will use facts, foibles, and exaggeration combined with an individual artistic style to communicate an opinion.

Learning Procedure

1. Share the Background section of this lesson and Resource section introduction on solid waste issues with the students.



Propped on the roof of the Hard-Rock Cafe in Los Angeles is an "environmental scoreboard" flashing environmental statistics linking world population and remaining acreage of the world's rainforest, designed to heighten environmental awareness of local motorists and passers-by.

Source: 1993 *Earth Journal*

9 - 12
PAGE
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2. Collect a week's worth of editorial pages from your local newspaper. Have students analyze your local editorial pages to determine:

- the issue being discussed
- the editorial writer's position on the issue
- the editorial cartoonist's position on the issue
- which tool, the editorial or the cartoon, communicates its message more directly (be sure to consider not just the graphic presentation but also the depth of the information presented)
- which tool tries to employ humor and which tries to present a well-reasoned argument.

3. Share the handout *Ariail's Environmental Comments* with the students. From the cartoons, have the students' reconstruct the issues that might have prompted these cartoons. (*NOTE: Some of these issues may be dated. See the brief descriptions or have the students research when these cartoon appeared in The State newspaper.*)

4. Have students choose an environmental issue, research the facts, write a description of the issue, form an opinion on the issue, and create their own editorial cartoon that expresses this opinion.

5. Have students present their cartoons to the class and defend their opinions.

Extension Activity

Have students research and write a report on early editorial cartoonists.

Ariail's Environmental Comments ***(A Teacher's Guide)***

A. Local governments in Columbia were considering legislation to reduce the number of billboards in and around the city. This issue caused some members of the advertising community to argue that this was a matter of restricting trade.

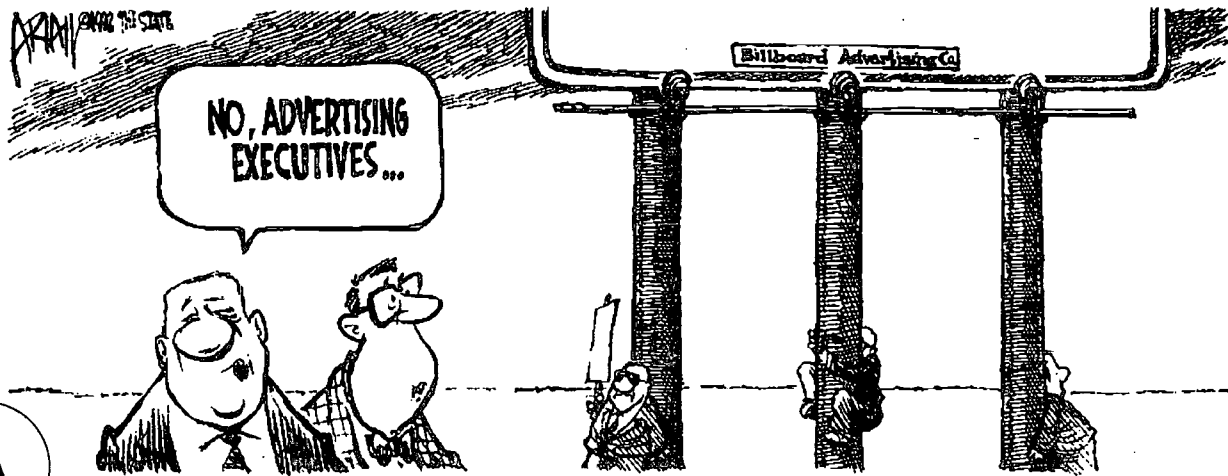
B. The *Greenville News* had uncovered files buried in the Richland County Landfill alleging unethical behavior by members of the University of South Carolina's administration. This cartoon appeared after that administration was dismissed and a new USC president had been hired. (This entire issue also points to an interesting environmental fact: nothing degrades in a landfill. Although the files had been buried in the landfill for a number of years, they were still legible.)

C. Commenting on voter backlash against incumbent politicians during the 1992 elections.

D. Appeared in the waning days of the Bush Administration that was accused of dragging its feet on taking actions to reduce greenhouse effect gasses that lead to Global Warming.

Ariail's Environmental Comments

These editorial cartoons are by The State newspaper's award-winning cartoonist Robert Ariail. They appeared in The State in 1991 and 1992 and have been reprinted in the book Ariail Attack. They are used here by permission of the author.

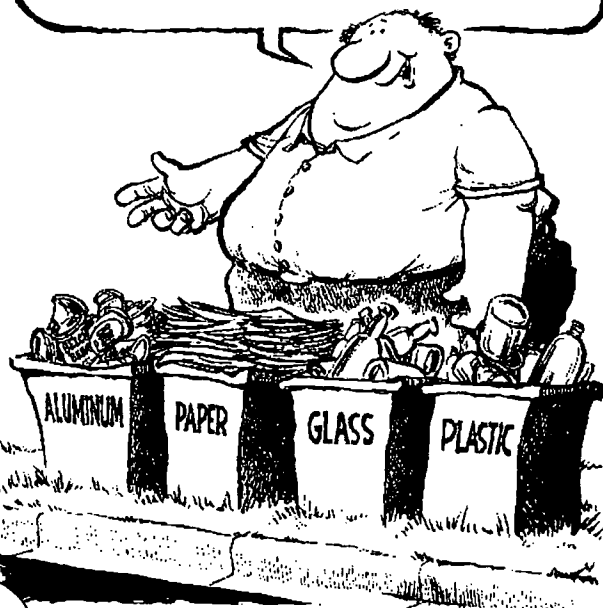


A



B

IN HONOR OF EARTH DAY, I'VE
STARTED SEPARATING GARBAGE INTO
CONTAINERS FOR THINGS THAT SHOULD
BE RECYCLED...

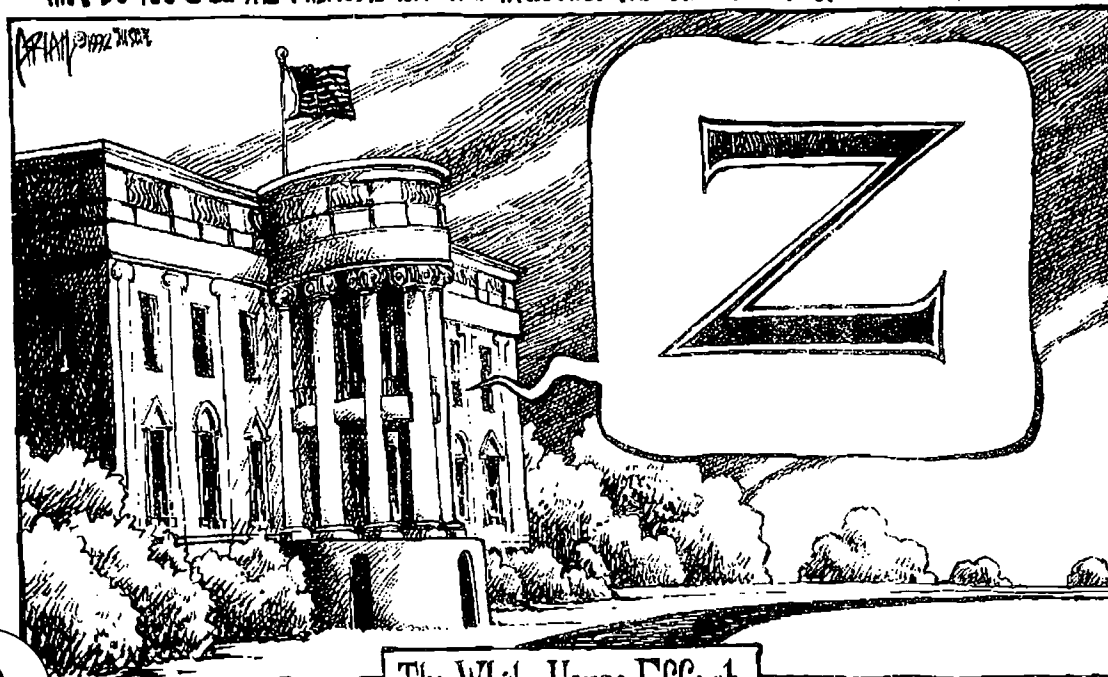


AND THINGS THAT
SHOULD BE
THROWN
OUT.



C

WHAT DO YOU CALL THE PHENOMENON THAT INCREASES THE LIKELIHOOD OF GLOBAL WARMING?



D

The White House Effect

Buy Recycled?

9.3R.14.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Consumer awareness, waste reduction and recycling, product packaging

Subjects: Home Economics, Environmental Science, Social Studies

Materials: School supplies made from recycled materials

Teaching Time: Several in-class periods, outside projects

Vocabulary: Solid waste stream, profit margin



Learning Objective

Students will:

- find out the reasons people in a grocery store buy certain food products
- determine the influence of packaging on consumer choices
- determine if consumers consider waste disposal and recycling when making buying decisions.

Background

Product packaging makes up a significant portion of our **solid waste stream**, what we throw away. In South Carolina, nearly 50 percent of all solid waste is glass, plastic, and paper.

According to South Carolina Department of Health and Environmental Control's 1995 figures, paper comprises 37.6 percent of the solid waste stream, plastic, 9.3 percent; and glass, 6.6 percent. Careful buying is the first step in solving the problem of too much solid waste. Consumers should consider waste disposal and recycling when deciding what to buy.

But there is a more important, less obvious force behind the "Buy Recycled" movement and that is simple economics. The economic principle of "supply and demand" is a major factor in bringing products with recycled content to the marketplace. The more consumers demand recycled products, the more the availability of these products will increase.

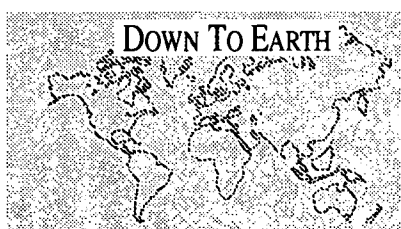
And manufacturers recognize their role in Buying Recycled. The Buy Recycled Business Alliance is a "national group of companies committed to increasing their purchases of recycled content products," according to their membership literature.

"Manufacturing and buying recycled products are no longer just 'environmentally friendly' things to do. Since today's consumers are expressing a clear preference for recycled content products, buying recycled makes good business sense for any company — whether it's a multinational corporation or a local business.



A Project
of The National
Recycling
Coalition, Inc.

"The Buy Recycled Business Alliance is a national effort by U.S. companies to promote market development and procurement of recycled content products. The Alliance is based on a spirit of partnership and



In 1991, Mexico's President Carlos Salinas de Gortari was awarded the Earth Prize, also called the "Green Nobel," for his environmental statesmanship. President Salinas was also presented the World Conservation Leadership Award in 1992.

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cooperation, and on the shared belief that market expansion is the most crucial factor to ensure the continued growth and economic development of recycled content products.

"Founded by the National Recycling Coalition, a non-profit organization representing diverse recycling interests, the Alliance has launched the Buy Recycled Campaign: a nationwide effort to encourage businesses of all sizes to increase the use of recycled content products in their day-to-day operations." In South Carolina, the Buy Recycled Business Alliance can be contacted through DHEC's Office of Solid Waste Reduction and Recycling at 1-800-SO-USE-IT.

In one very clear example of the type of recycled content efforts made by one corporation, consider a hamburger chain's story: McDonald's. The McDonald's Corp. made a corporate commitment to purchase products with recycled materials wherever practical ... and practicality is a major factor. McDonald's was buying paper napkins made from virgin materials. To purchase the same napkins made from recycled paper would add \$1 million to their napkin costs ... not a practical option.

However, if each napkin's overall size were just 10 percent smaller, the cost of using recycled material to manufacture the napkins would remain the same. Today McDonald's recycled-material napkins, when unfolded all the way, are 10 percent smaller than they used to be, hardly a significant difference when used by their customers. The napkins are still folded to the same size so they will fit the millions of napkin dispensers across America. And they cost the same as the virgin material napkins.

The more people "Buy Recycled," the more recycled products there will be to buy. And this will help recycling collection programs find new markets for the items that they collect. "Buying Recycled" will also fuel developments in new technologies for recycling products.

The consumer plays a significant role in the Buy

Recycled circle. However, the consumer must be an informed buyer. Many products carry meaningless environmental claims. For example: "Earth-Friendly" is a term that has no legal or environmental meaning.



Organizations such as Scientific Certification Systems (SCS) are working to establish environmental standards to certify manufacturers environmental claims. Their Green Cross and Globe emblem on certified products is accompanied by "precise information about the environmental achievements which have been verified." SCS has published some general guidelines to help consumers "decipher fact from fiction." These guidelines, reprinted from SCS's *Consumer Guide to Environmental Claims in the Marketplace*, are:

"1. All Products Have An Impact on the Environment

Every product involves the use of resources and energy at some point in its production, use, or disposal. Solid and hazardous wastes may also be generated. Even products which perform a valuable environmental function (for example, water-saving shower heads) are not without some environmental impact. Watch out for vague claims like 'environmentally friendly' and 'safe for the environment' which may promise more than they deliver. Also be on the look-out for environmentally suggestive packaging or symbols which may leave a strong impression but don't add up to much.

"2. Specific Claims are Best

The more specific the claim, the better. Specific claims are easier to understand, easier to verify, and less likely to be misleading. For example, many people are confused by the three-arrow recycling symbol. Sometimes, the symbol is used to indicate that a product is recyclable. Other times, it indicates that a product is made, at least in part, from

recycled materials. Look for this distinction. Recycled content claims should always indicate an actual percentage (from 1-100 percent).

“3. Significant Achievements Deserve Recognition

Not every environmental claim represents a significant achievement or improvement. In fact, in their rush to jump on the environmental bandwagon, some companies have resorted to making trivial or irrelevant claims. For example, what makes one paper napkin more “landfill safe” than another? Not much, since the landfill, not the product, is the primary determining factor. And what about a product that suddenly advertises ‘no CFCs’, when in fact, no chlorofluorocarbons (CFCs) have been allowed for 15 years? By being selective, you can give the right kind of encouragement to manufacturers.

“4. Claims Should Be Verified

Every company should be able to provide detailed documentation to support the claims they make. Don’t be shy about asking. Some companies are having their claims independently verified for added assurance by organizations like Scientific Certification Systems. Find out about the group doing the certification to make sure there are no conflicts of interest. If your store is making the claim, ask what steps have been taken to verify the accuracy of the claim.”

Learning Procedure

Part One

1. Share the Background information included in this lesson with the class. As a group, have the class develop a questionnaire to use to interview people or a family member in a grocery store about the reasons they buy the items in their grocery carts. (A sample is included with this lesson.)

Ask: Which of the following factors influenced your decision to buy this product?

- The cost.
- The convenience in preparation.
- I saw it advertised.
- High nutritional value.
- Lack of artificial coloring, flavoring, or

preservatives.

- The packaging is reusable/recyclable.
- I am having company, it is a special purchase.
- I am trying something new.
- It has catchy packaging - visually attractive.
- A friend recommended it.
- It was on sale.
- Buying it for the kids.
- Uses less packaging than other brands.
- I’ve used this product before.

Ask: Does the recyclability of the product or its package play a part in determining what you buy?

Ask: When buying, do you think of how easy or difficult the product or its package will be to dispose of when you are finished with it?

2. Assign students to conduct the survey with family members or with the cooperation of a local grocery store. This can be done individually or in teams. Be sure to ask about six or seven items in the interview subject’s shopping cart.

3. As a class, discuss the results of different team’s survey. Analyze and chart the results of your class findings.

- Which were the most common reasons for buying a food product?
- How often was recyclability taken into account?
- Were people concerned about waste disposal when deciding what to buy?
- Were people even aware of solid waste disposal issues?

Part Two

(Note: This will require the cooperation of the manager of the School Store. If your school does not have a store, you might consider setting up a temporary store for this portion of the lesson.)

1. Ask the students if they would be willing to choose a product if it was made from recycled materials. Ask if they would be willing to pay more for a recycled product if the quality was comparable

to a similar, nonrecycled product.

2. In the school, store offer products such as pencils, paper, and notebooks made from virgin, nonrecycled materials and recycled materials. Offer them side-by-side with signs clearly advertising the recycled content of one set of products. *Make sure the products have the same price.* Be sure to note each product's **profit margin**, that is, what the store "makes" on each product sold. Calculate this by subtracting the original cost of the product (the store's cost) from what you sell it for. Track the sales of each product for a week and graph your progress.

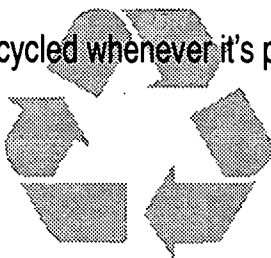
3. Using the same set up, raise the price of the recycled products by 10 percent. Be sure to note the new profit margin on each product. Track the sales of nonrecycled and recycled products for a week and graph your progress.

4. The third week, raise the price of the recycled products another 10 percent. Be sure to note the new profit margin on each product. Track the sales of nonrecycled and recycled products for a week and graph your progress.

5. At the end of three weeks take inventory and compare the sales figures. How did sales of the nonrecycled products compare with the recycled products over three weeks? When the prices were the same, did buyers choose one product over another? Did a higher price influence buyers to choose one product over another? How did changing the price affect overall weekly profits for the store? What role did advertising (the in-store signage) play in influencing buying decisions?

Just Do It

Buy recycled whenever it's practical.



Questions for the Class

1. How frequently do purchasers consider how packaging contributes to waste when shopping?
2. Does a "Recycled" or some other type of environmental benefit statement on packaging boost product sales?
3. Does an environmental statement on packaging boost sales even if the price is higher?
4. Is there a price-tolerance level?
5. Do people believe environmental benefit statements on product packages.

Extension Activities

1. Repeat the survey from Part One with students in the School Store. How did their answers compare to the "real world" answers obtained originally?
2. Many countries, states, and cities have regulations that require recycling and waste reduction. In South Carolina, each county or region is required by law to have a waste management plan in place. Have the class find out the regulations and waste disposal and recycling options in your area. To get started, call the S.C. DHEC, 1-800-SO-USE-T for information, or call your county government.
3. With improvements in recycling technology, products with recycled content are priced competitively with products made from virgin materials. Have students survey the prices of several recycled products with those of products made from virgin content. Items to survey may include paper or plastic products.

STUDENT WORK SHEET SHOPPING SURVEY ... WHY WE BUY IT.

When shopping, do you think about the product and its packaging and the waste?

_____ Yes _____ No _____ Sometimes

Factors that influence people's buying decisions (*check those that apply, write answer for other*)

Cost

Convenience

Advertising

Nutrition

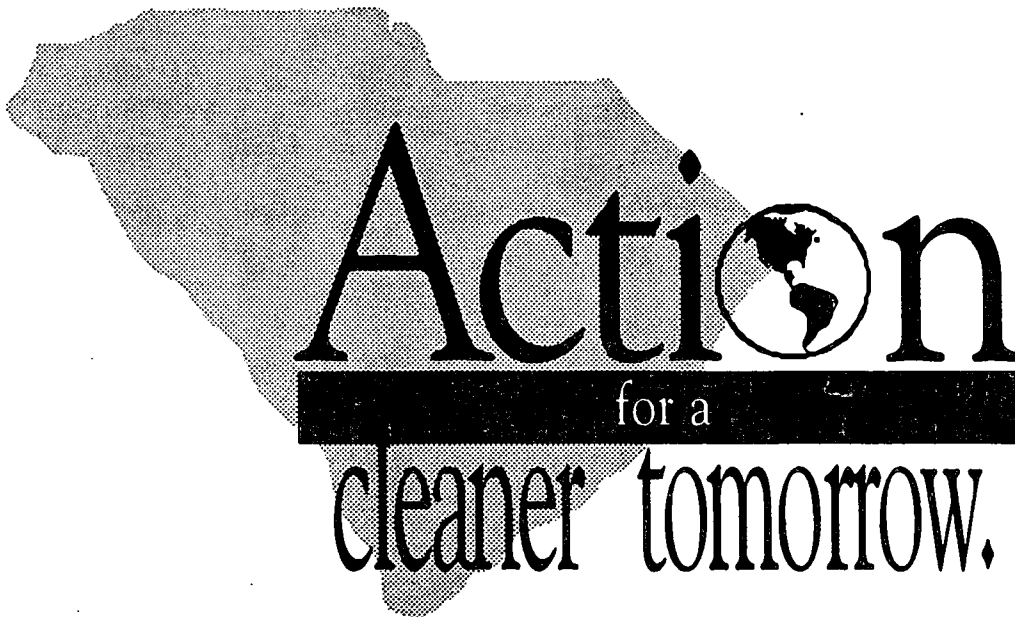
Reusable or
recyclable

It's new

Other

Item/Brand

A full page of blank graph paper. The grid consists of 10 columns and 10 rows of squares, formed by thin black lines. There are no margins or other markings on the page.



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Creative Conservation

9.NR.5.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 11 – 12

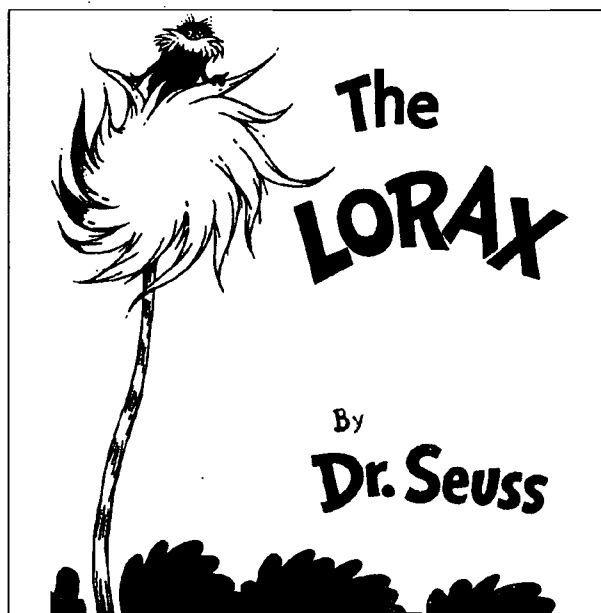
Focus: Examining our “throwaway” lifestyle through creative writing and poetry.

Subject: English

Materials: References on poetry forms; bulletin board space or poster board; examples of haiku, couplet, limerick, free verse, and cinquain poetry, *The Lorax* by Dr. Seuss, *A Description of a City Shower* by Jonathan Swift. For Extension Activities: *The Wasteland* by T.S. Eliot.

Teaching Time: Two class periods, plus homework assignment

Vocabulary: Waste, hazardous, nonhazardous, biodegradable, nonbiodegradable, planned obsolescence, throwaway lifestyle



Learning Objective

Students will:

- define the term “waste” and describe four waste categories
- write poems to express their thoughts about the social issue of waste.

Background

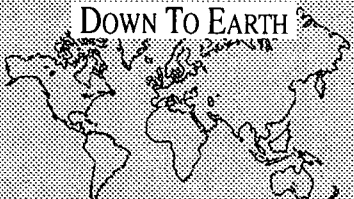
One traditional use of poetry has been to express views on social issues or conditions, and examples of such poetry provide a valuable record of the development of human societies.

One of the most important issues today is that of waste and our management of waste to protect our environment. **Waste** is defined as any material that is discarded, useless, or unwanted. Some waste is not hazardous to us or our environment (**nonhazardous**); however, some is extremely **hazardous** or dangerous to plants and animals.

Wastes from natural materials can be broken down into simpler compounds by microorganisms and are referred to as being **biodegradable**; wastes from human-made products, such as plastics, glass and aluminum, cannot be broken down by microorganisms (**nonbiodegradable**).

Even waste that can be broken down must be handled to allow that process to take place. For example, grass clippings put in the trash and taken to the landfill will not break down; they are preserved in the landfill. Materials that can be broken down must be processed in waste management systems designed to allow decomposition, such as compost piles.

Many of our products are designed to be used only once and then thrown away; these items contribute to ours being called a **throwaway lifestyle**. Other products are designed to become obsolete, or useless in a short period of time (**planned**



In the United States, Turner Broadcasting created and produces a children's environmental cartoon called *Captain Planet*.

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obsolescence). We seldom stop to think about where the materials for these products come from or that the natural resources for these materials are limited. Likewise, we seldom think about where discarded items are taken or that land available for their disposal is limited.

Learning Procedure

1. The purpose of this activity is to evaluate the issue of waste and respond through the art of creative writing or poetry.

Share with the class, *The Lorax* by Dr. Seuss and discuss:

- a. how the story uses humor and rhyme to make a point about waste and wasteful habits
- b. how the story has appeal for all ages.

For more advanced classes, share with the class "A Description of a City Shower," by Jonathan Swift, and discuss:

- a. the poetry form used and what that says about the poet
- b. the language used to evoke sensory images
- c. the main purpose of the poem
- d. Swift's attitude toward change as it might relate to the social issue of waste today.

2. Explain to the students that they will be writing poems in the forms of their choice (couplet, haiku, limerick, cinquain, or free verse) about the social issue of waste.

3. Review with the students what they have learned about metaphors, similes, rhyme, alliteration, and onomatopoeia.

4. Review the background material for this lesson and the Solid Waste introduction in the Resource section. Discuss with students the concepts of "planned obsolescence" and "throwaway" lifestyles as they relate to the students' lives.

5. Assign each student to find a picture that illustrates an aspect of waste in terms of the class discussion. Have them find pictures that show their personal response to the issue, using newspapers, magazines, or photocopies from library journals. For example, if students believe that waste is encouraged through convenience items, they might create a collage of convenience-product advertising.

6. As a homework assignment, have each student write a poem in the form of his/her choice and use the picture as an illustration for the poem.

7. In class, ask the students to share their pictures and poems. Open the classroom for discussion as each poem is read. Identify the form of the poem, the language used to evoke images, and the message the poem imparts.

Extension Activities

1. Have students read "The Wasteland," by T.S. Eliot and discuss.

2. Have the class organize a poll of other students in the school concerning the issue of waste. Publish the results of the survey and the poems your class wrote in the school newspaper.

Questions for the Class

1. Define the term "waste." Identify four categories of waste and give an example of each.
2. What does poetry have to do with the social issue of waste?



Lights, Camera, Action

9.3R.5.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Using television and promotional announcements to show that protecting the environment is desirable

Subjects: English, Speech, Drama, Social Studies

Materials: See list of materials itemized below

Teaching Time: Several class periods (not including actual production time for commercials)

Vocabulary: Public service announcement

Learning Objective

Students will:

- identify some of the influences, appeals, and techniques advertisers use to promote products
- see how these techniques are also useful in educating and persuading the public on environmental issues.

In this activity, students will take a look at how commercials are designed to sell products and how commercials or **public service announcements** (*messages that are printed or broadcast for no charge*) can be used to “sell” products or ideas that protect the environment.

Students will design and produce their own environmental public service announcements or advertisements for environmentally sound products.

This activity is a cooperative learning activity with students working in groups of four or five.

Materials

For television production: video camera, blank video tape, VCR, tape recorder, pencils, paper, tape,



markers, resource books, pretaped commercials.

Handout for students: *Writing and Producing Your Own TV Commercial*.

(Note: You may want to contact your local television station for help with this project.)

For print projects: art paper and drawing supplies such as markers. For classes with photography capabilities, encourage students to use original photographs in their print advertisements where appropriate.



Of the 88 advertising claims investigated by the National Advertising Division of the Council of Better Business Bureaus, 16 were about environmental claims. In two-thirds of the cases the offending companies changed or dropped their claims.

Source: *The Green Consumer*

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Learning Procedure

Day One

1. Discuss the important elements of effective advertising such as: targeting a specific audience, presenting a unique product advantage, style, visuals, delivery, eye appeal, and other considerations. Also, discuss the difference between public service announcements, PSAs, (*non-paid messages that are broadcast as a service to the public, examples include messages from the Heart Association or other organizations that service the public*) and paid advertising (*commercials that the advertiser pays to have broadcast*).

The student handouts may be copied and distributed to students to provide technical background information for developing commercials.

Day Two

2. Have students view and discuss various TV commercials (*you will need to pre-tape before session*) and various print ads for products and services. These should include a mix of products and messages that promote protecting the environment and ads for products that can cause environmental problems if not handled properly.

Discuss how the commercials make their points. Could the commercials be changed to reduce the environmental consequences of the product or to promote better environmental habits? (*For example, could commercials for canned soft drinks promote recycling the cans or could commercials for paper products remind people not to litter but to recycle?*)

Day Three

3. After students have a feel for the commercials, divide the class into groups. Have each group select a specific topic. (*A product, service or position to promote. Students should identify a product such as a cleaner, hair care product or agricultural product; or a service such as lawn care or automotive repairs; or a position such as recycling is good for the community.*) Allow them time to discuss and begin to brainstorm ideas for their own commercials. Bring the whole group together to share ideas and generate new ones.

Day Four

4. As a group, students should be allowed to choose the media for their commercial.

- **print:** newspaper, magazine, direct mail;
- **broadcast:** 30- or 60-second TV commercial or public service announcement, or radio spot
- **outdoor:** billboard, bus board or other).

Encourage the use of props, cue cards, role playing, costumes, photography or illustration, or whatever tools are available to produce finished-quality communications.

Give students about a week to complete the production of their ads. Schedule presentation of the finished ads to the class.

Day Five

5. Present the commercials to the class, and/or ideally, to another group (younger children, adults, community leaders, etc.).

Extension Activities

1. Contact a local advertising company and invite a speaker in to talk about advertising the environmental positives of a product and the trend toward "Green Products" and "Green Advertising."
2. Have students write the National Advertising Division, Council of Better Business Bureaus, 845 Third Avenue, New York, NY 10022, for more information about how environmental claims are investigated.

Just Do It

Pay attention to the environmental claims made on the products you buy.
How are they backed up?
If a product you buy has a vague environmental claim, write the manufacturer and ask for more information.

Student Handout

WRITING AND PRODUCING YOUR OWN TV COMMERCIAL

It starts with an idea.

The first thing you'll need to write and produce your own TV spot is an idea. Ask yourself these questions:

- What message do I want to convey?
- Who am I trying to reach with this message?

(Who is the audience? How old are they? Are they men and women, are they teenagers, are they kids? What do I know about the audience, their economic position, their likes and dislikes?)

- How can I present this message in a way that is clear and will attract the attention of the target audience?
- What action do I want the target audience to take after seeing the commercial?
- Can I make my commercial an interesting 30 second story?

Turn your idea into words.

Once you have your idea, turn it into words. Let's say your idea is to show what happens to a soft drink container after the contents have been consumed. Will you use actors or an off-camera announcer? Write down one or more possible scripts - figuring about two words per second. If you intend to have all of your 30 second spot filled with talking, that means you should write 55 to 65 words. If only part of your spot has dialogue or speaking, you'll want to use fewer words. After writing your script, read it out loud. Does it sound realistic... does it sound natural? How will this message appeal to your target audience? Keep writing and re-writing your script until it sounds believable and makes a statement that people will listen to and understand. Make sure your beginning words draw people into the spot... and that your ending is either powerful, humorous, or memorable.

Turn your idea and words into pictures.

TV communicates with images. Take advantage of that by thinking of the strongest, most vivid, most

imaginative pictures that you can. Again, going back to our example of a soft drink container - what could you do to make that image as dramatic as possible? Put it in a spotlight? Show it through a dense fog of smoke? Photograph it from up close? Have a pile of smashed and unsmashed cans instead of just one? Show a container being cast off into a ditch or being added to the pile? These are all visual possibilities. Your own mind is the only limit to what you can show. Think graphically... and let your pictures carry the emotion and impact of your commercial.

Putting the words and pictures together.

Take a blank sheet of paper, and draw a line from top to bottom down the middle. On the left-hand side you will write all your visuals. Describe each visual action in detail. For example, camera moves in right to a container in the hand. The hand moves outward to toss the container toward the pile. The pile is scattered and broken with additional debris. On the right hand side of the paper, write down your words or copy so that your dialogue or off-camera announcer's words are written down next to the visual action that takes place at the same time. In other words, if your announcer says "here, you can be a part of the problem or the solution." Write those words next to the picture of the action that takes place at that time. By writing down the visual action and words next to each other on the paper, you can tell at a glance, exactly what is going to be happening - words and pictures together - in your spot.

The Storyboard tells the story.

What follows is a storyboard. In each frame, sketch a rough picture of what you'll show on the screen. Under each frame, describe what is happening, and write the dialogue that goes with that picture.

Rehearsing and planning are important.

Several days before your scheduled shooting date, take your storyboard and talk to the director of the commercial about it. Together you can plan how you will shoot the spot. Also, you'll want to decide what props you need. You must have all your props together before you shoot the commercial.

In addition, if you are using actors, have them fully rehearsed so you don't waste time in the studio. If you are using any other elements, such as a piece of music or an off-camera announcer, it would be wise to have these audio elements already recorded before you go into a video studio.

Your judgement makes the difference.

This is the time when your concept comes to fruition. In the capable hands of the director, cameraman, acting and voice talent, and video technicians, your idea should come off without a hitch, provided you have preplanned everything with care. So, your job during the actual production of the spot is to offer opinions and feelings about what is going on. The director's job is to instruct the crew and talent.

Putting it all together.

Sometimes, your commercial cannot be shot in a single, 30-second "take." In such a case, your spot will be filmed in short sequences and edited together. This takes place after the spot has been shot. Editing the spot, or putting it all together, can take a few minutes, or several hours depending on how many scenes have to be edited together. If your spot takes place in a single setting, with little action, editing time will be short. On the other hand, if you are cutting back and forth from scene-to-scene... or if you are changing your pictures to coincide with a piece of music, the editing process can be time consuming.

Your message is ready!

It is finished... and it represents a lot of hard work – and plenty of fun – by everyone who contributed. The important thing is that you created something that reflects your views on an important subject... and you learned a lot about writing and producing television along the way!

Adapted from:
Writing and Producing Your
Own TV Commercial
You Can Do It
KidVid Project, KTIV Channel 4 and
Siouxland CARES, Sioux City, Iowa

STORYBOARD GUIDELINES:

On the radio, only words are used to get a message across. In video, the message has to be conveyed with the help of pictures. You need to show your audience, don't just tell them.

A storyboard is similar to a comic strip. The action unfolds in a series of still pictures.

Narration, dialogue, music, sound effects and camera movements are written under or next to each frame.

Steps in Storyboard Production

1. Get a picture in your mind of what you would like to show your audience. The visual aspect of your message should go along with the words you've written, but should add interest or excitement to that message.

A good thing to do is think of what on TV appeals to you. What messages do you remember, and how were they conveyed?

2. Start drawing pictures of your message. Draw a picture of each separate part of the message.

3. Look over the pictures you've drawn. Now think about how you'll present those pictures in front of a camera, not a video camera, just your parents' 35mm camera, for example.

4. Work your pictures into individual frames for the camera. Each frame should be related, together they should show some continuity of action.

You can add interest to the pictures if you imagine yourself to be a professional photographer, taking pictures from all different angles, all different zooms.

Decide which angles and which zooms look best. Once you've drawn each camera frame of your message, you've got a storyboard.

5. Now consider how the action in your pictures would look in video. Think of the pictures you've drawn as one continuous action story. How would you bring those pictures to life? How would you act them out?

Rehearse before you get in front of the camera. But once you are in front of it, try to forget it's there. By pretending you're still just rehearsing, you'll be less nervous and more natural. That's one of the keys to an effective message.

Camera Guidelines

If you shoot your commercial in a studio, you may be able to use two cameras; keep this in mind as you draw your storyboard and write your script instructions.

Let's say Camera 1 is set up directly in front of the scene to take a wide shot of all the action. Perhaps camera 2 can be set at a 45-degree angle to the scene, zoomed in to a close-up shot of whatever action is taking place.

Your script will have to designate which camera is in use for each shot. Your storyboard will need to show the type of shot you have planned.

Low angle shot—The camera is close to the ground looking up at the subject. This makes the subject bigger, more dominant in the viewer's mind. The viewer may feel less in control or less superior.

Focal point— Close-up shot of a still item.

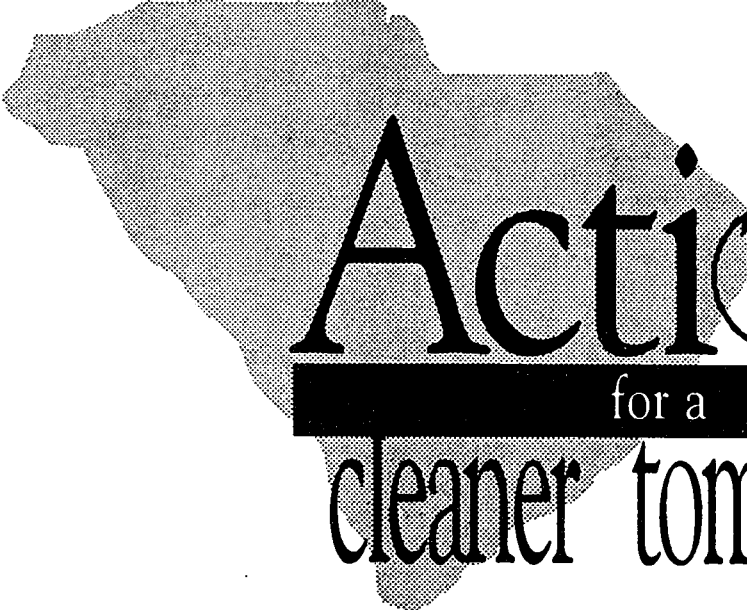
Wide shot—Takes in the whole scene or entire person.

High angle shot—The camera is higher than the action looking down on it. This tends to make the action or speaker smaller or less important in the eye of the viewer. Viewers may feel a sense of superiority when viewing this angle.

Close-up – Tight on the head or on the action.

Extreme close up – One element of the action or of the person's face.

Medium shot – Usually head and shoulders from the waist up.



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Where Does the Good Stuff Go?

9.3R.6.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 10 - 12

Focus: Throwaway society, responsible consumerism

Subjects: Environmental Science, Social Studies, Home Economics

Materials: Items that are suitable for reuse, map of your community

Teaching Time: Several class periods. Note that students need time to work on refurbishing items, and to complete home assignments, so the other class periods should not be planned as immediately consecutive.

Vocabulary: Refurbish, reuse, recycle

Prerequisite: My Bag lesson



Learning Procedure

This lesson studies the many options to throwing away items and how many items can be **refurbished** (*repaired and made useful again*) and reused.

1. As a class, make a list of items that are often thrown away but could be reused. (*NOTE: **Reused** means that the item essentially is unchanged from its original purpose or form. **Recycled** means the item is significantly changed before being made into a new product.*) Reuse items may include: jewelry, appliances, toys, cars, antiques, clothing, military surplus, and furniture.

Show students items you've collected that can be reused. These items may include clothing, used household items, repairable small appliances.

2. As a class, make a list of agencies that collect, refurbish and sell or distribute usable merchandise. This list will grow as the lesson continues. These places include: second hand stores, Goodwill Industries, antique stores, near new shops, and army

Learning Objective

Students will:

- understand that there are options to trashing used goods
- list reuse of goods as an option to landfill disposal and recycling
- list agencies that collect, refurbish, and sell or distribute used items
- list benefits to individuals and society reusing goods
- cite examples of how ancestors dealt with shortages of clothing, building materials and equipment.

Background

The United States has a reputation as a throwaway society. Yet, if students study their heritage, follow a Goodwill Industries collection truck, price a vintage car, or browse an antique shop; they will discover all the good stuff doesn't get thrown into the trash and doesn't go to the landfill. It is important that students realize there are responsible options to trashing goods they no longer want or need.

DOWN TO EARTH



Many people believe that projected landfill capacity estimates are inaccurate. Pennsylvania, for example, had 72 landfills for municipal waste in 1989 and a projected life span of five years. By 1991, it had only 44 remaining landfills, but had increased its estimated remaining capacity to 15 years. Why? Landfill sizes are increasing.

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surplus. Items can be given away or resold at reduced prices.

Have students locate these places on a map of your town or community.

Ask students: Why do you think America is referred to as a throwaway society? (*our preference for new things, designed obsolescence, advertising, poor quality of some non-durable goods, convenience, the fact that it is less costly to buy new than to repair*)

3. Invite a speaker, or discuss with the class, how our grandparents reused goods during the Great Depression or during World War II. Have them discuss the practice of turning collars and cuffs on shirts, furniture passed from generation to generation. How everything - string, feed sacks, wax paper, paper sacks, grease - was reused.

4. Discuss and assign the students projects. (*See handout.*)

Alternative

Take a class field trip to one of the collecting agencies. Have each student bring the item they refurbished to the collection center and follow the sorting/distribution path for their item. (*Several agencies welcome tours.*)

Questions for the Class

1. List your reasons for reusing goods. (*cost is less, more ecological, only way to find some goods, quality of items, style of items is unique*)

2. Suggest reasons why many people shop at reuse centers. (*money savings i.e. bargains, just like the challenge, fun*)

Extension Activities

1. Predict possible effects of an economic recession on reuse agencies and on the people using reuse centers. (*fewer items donated, fewer items available, the lower income people using the agencies could experience greater economic hardship*)

2. Suggest reasons for and against using tax dollars (municipal funding) to supplement reuse agencies financially.

(*For: reduced landfill cost – pass savings onto agencies.*)

(*Against: greater burden on taxpayers.*)

Reuse agencies receive most of their donations from middle income people. Suggest ways to include other income levels in the reuse programs.

(*Enlist community groups i.e. churches special targeted mailings, advertising campaigns*)

3. List ecological and economic impacts on a municipality if reuse agencies were not available.

(*Landfills have limited space, therefore:*

1. *greater distances to haul*
2. *higher cost as landfills fill*
3. *loss of valuable resources, land, usable items*
4. *economic hardship.*)

4. Could a reuse agency contribute to the effects of an economic recession?

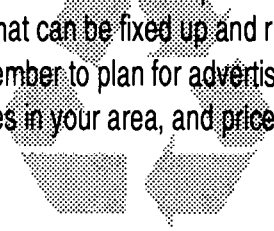
(*Possibly: not buying new items could drive down cost and demand, could contribute to unemployment and recession.*)

5. Why are some used items very valuable, i.e. antiques?

(*Supply and demand – people want them! Trends – antique furniture and cars*)

Just Do It

Consider using a thrift store as a fund raiser for one of your school clubs. Explore sources of donations that can be fixed up and repaired for resale. Remember to plan for advertising to target needy families in your area, and price items fairly.



Refurbishing Assignment

Date Due:

You may choose one of two options for this assignment.

Option 1: Find an item in your home that is unwanted and is going to be thrown away (be sure you have permission to use the item). The item may be a personal item, something from your family, something from a neighbor. Your assignment is to refurbish or find a way to reuse the item. Be prepared to bring in the “new” refurbished item and give a short oral presentation describing the following:

- a) the object before you rescued it from being trashed.
- b) what you did to the object to refurbish it for reuse.
- c) what you are going to do with the item now.


You will need to turn in the item along with a one page report covering the three points above.

Option 2: Interview a representative from an agency that processes usable, discarded goods. Consider and plan your questions in advance. Suggested questions are offered below. You will turn in a written report on your interview and make a brief, oral presentation on your findings. Your written report should include your interview questions and answers and your impressions of the facility you visited and the work done.

Sample questions:

- What is the goal or mission of the reuse agency?
- Where do the donations come from? Who donates the items?
- Who benefits most from the agency?
- What are the most commonly donated items?
- Which donated items are not valuable for resale?
- What happens to unusable or unsold items?
- How are the profits from resale of items used?
- Does your agency receive financial assistance from any outside source. i.e. church, government, service organization?

For this interview, please remember to call in advance, politely explain your assignment, ask for an appointment, be on time, and thank the person for their time. If you would like to use a tape recorder to capture what is said in the actual interview, please ask for permission in advance.



Action

for a

cleaner tomorrow.

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Poetry for Solid Waste

9.RE.5.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: Using poetry to communicate the benefits of recycling.

Subjects: English, Environmental Science

Materials: Writing materials, student copies of poem types (optional)

Teaching Time: Two class periods

Vocabulary: Cinquain, haiku, diamante

Oil pools from dead remains
Diamonds from the same place, too
Both precious, highly valued
A simple matter of pressure.



Learning Objective

Students will:

- see how poetry can be used to communicate ideas and feelings about environmental issues
- write poetry related to recycling.

Everyone can be a poet, at least to some extent — and yet lots of people think any kind of poet's expression is beyond their capacities. This activity is designed for every student — or group of students — to create a poem.

poem while others discuss their experiences in being concerned about recycling.

Here are a few examples of poetic forms that can be used. These have been excerpted and adopted from Project Wild, Secondary, 1983, 1985, Western Regional Environmental Education Council, and previously from Project Learning Tree (Washington, D.C. American Forest Institute, 1977).

Learning Procedure

1. Discuss with students the use of poetry to express thoughts and feelings about environmental issues. Share with students the poems included with this lesson and others that you may enjoy. Tell students for this poetry writing activity, poems can be free verse or rhyming. Cinquain and haiku are interesting forms that students may want to try.

For group poetry writing, every person thinks of a thing about waste or recycling. Each person contributes one word. One or more students or the teacher can put all the words together to form the

Haiku – Haiku, originated by the Japanese, consists of three lines of five, seven, and five syllables each. The emphasis is syllabic not rhyming. For example:

*aluminum can
made into a useful tool
guide to harmony*

Cinquain – Cinquain is derived from the French and Spanish words for five. This form of poetry is also based on syllables — or may be based on number of words — but there are five lines.



"Understanding that the world does not belong to any one nation or generation, and sharing a spirit of utmost urgency, we dedicate ourselves to undertake bold action to cherish and protect the environment of our planetary home."

Vice President Al Gore, Earth in the Balance

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Each line has a mandatory purpose and number of syllables or words. These are: 1) the title in two syllables (or two words); 2) a description of the title in four syllables (or words); 3) a description of the action in six syllables (or words); 4) a description of a feeling in eight syllables (or words); and 5) another word for the title in two syllables (or words). Here are two examples, the first using syllables and the second using words:

paper
vital, useful
remade to serve again
too often wasted by us all
unfair

cardboard box
containers of our things
holds, protects, surrounds, stores, carries, covers
convenient, useful, inexpensive, adaptable,
strong for its weight
unlimited uses

Diamante – Diamante is a poem shaped in the form of a diamond. It can be used to show the words are related through shades of meaning from one extreme to the opposite extreme, and beginning and ending nouns could be natural resources. A pattern of parts of speech are as follows:

noun
adjective adjective
participle participle participle
noun noun noun noun
participle participle participle
adjective adjective
noun

Example:

sapling
taller thicker
living growing maturing
wood paper printed read
bundled reformed fiber-board
wall construction
house

The completed poems can be typed or printed neatly — and then displayed with a photograph or black and white pen and ink drawing of the product. Here is an example of free verse with a drawing:

Seed
sun soil rain
roots, stem, branches, leaves
longer, stronger, wider, taller
grows into wood, cut for lumber, used to build
to construct, used for script, for packaging
first one use, then another, another
never discarded, nor lost
many many uses
none wasted
precious

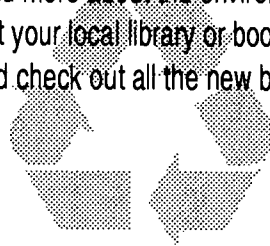


Extension Activity

1. Send your recycling poetry to the school or local newspaper to be published and read by others.
2. Poems can be laminated and used for placemats in the school cafeteria as part of your school's Earth Day celebrations.
3. Compile your students' work into a book of poetry. Printed on recycled paper, this may be sold as a fund raiser.

Just Do It

Read more about the environment.
 Visit your local library or bookstore
 and check out all the new books!



The End Of The Road

9.RE.6.F

Preparation Time: Easy-To-Do Moderate Extensive

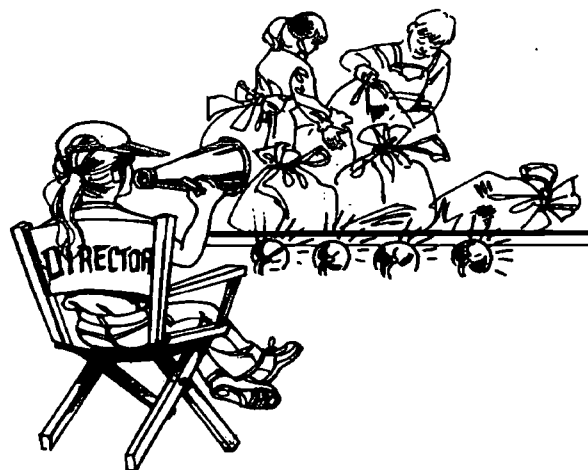
Grade: 9 – 12

Focus: Using dramatic arts to teach the merits of waste reduction and recycling.

Subjects: Drama, English, Art, Social Studies

Materials: See list of materials itemized below

Teaching Time: Two class periods



Learning Objective

Students will:

- write the script for a play, which they will also perform, to encourage consumers to recycle and to reuse.

Materials

Materials for producing play (with this lesson) can be assigned to students. Encourage students to reuse waste materials where possible to produce a "green production." Materials include:

- Backdrop of a typical kitchen
- Scene 1 Props: papers, cans, bottles, and large plastic bags
- Scene 2 Props: box, cans, bottles, paper, and plastic milk jugs
- Scene 3 Props: a recycle bin with four compartments marked paper, plastic, glass, and cans
- Costumes: Will & Mae, Al-Can, Jill Jar, Patty Paper, and Peter Plastic.

Background

It is estimated that more than half of American waste is recyclable. On a national level, experts project that 25 to 30 percent could be composted (a form of natural recycling) and 40 to 50 percent of the waste stream could be recycled.

Along with the amount of waste that could be reduced through other methods, the amount of waste going to our incinerators and landfills could be reduced by as much as 70 percent.

For more information about solid waste and recycling, see the Resource section.

Learning Procedure

1. Review with the class basic information about solid waste and reusing, reducing, and recycling methods. Also review with the class the methods that are currently available in your area to reduce the total amount of waste going to the local landfill and/or incinerator. If your area does not currently have any structured recycling program, this play can be used as a tool to educate students and the community about taking action now.

2. Use the information provided in the following skit (or a skit and characters created by students), and have the class write a script and perform the play for elementary students, the local parent/teacher association, or a community meeting on local issues.



In 1991, the U.S. Conference of Mayors reported that more than half of the nation's cities have less than a decade of capacity remaining in existing landfills.

Source: *What Can I Do To Make A Difference*

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Outline for the Play:

END OF THE ROAD

Scene I

Mae and Will Waste's kitchen on Evermore Drive. Mae and Will are overstuffing big plastic garbage bags with papers, cans, and bottles.

Mae laments the TV commercials that say the garbage bags will not break. She feels they never hold enough. Will reminds her that trash is piled four feet deep in plastic bags all through their backyard, and that no more waste will fit out there.

Mae longs for the good old days when the landfill was open and the big truck came and picked their garbage up every week and took it "away." Will says the landfill had to fill up eventually, and that there is no "away," and that there really never was.

While Will leaves to take the trash out, Mae is greeted by a strange looking creature named Al-Can. Al-Can is sad because he is in his prime, feeling strong and vigorous, but instead of putting him to work, they are throwing him away. Al-Can claims to have part of the solution to their trash problem. He says all those aluminum cans they have been throwing away are very valuable. If they collected their aluminum cans, they would not only make a little money, but would also cut down on trash. Al-Can goes outside to look at all the trash.

Mae is delighted and calls Will. Will laughs at her, telling her he never heard of a talking can. After Mae leaves, Will is confronted by a glass jar named Jill Jar. The jar tells him that glass is valuable and that if he would collect all his glass jars and bottles and take them to the recycling center, he would be saving valuable resources and energy. She asks him to think about the heat and energy that it took to make her lovely shaped clear exterior, and that it would be a shame to waste all of that by throwing her away.

When Mae returns, they are both confronted by Patty Paper who wants to be used again. She states she's tired of lying around, she still feels young and there's a lot of life in her yet. She doesn't want to go "up in smoke." Mae and Will decide to collect their

cans, glass bottles, and papers and take them to the local recycling center.

Scene II

Later, Will and Mae are excitedly discussing what they will do now that they have a clean yard and some extra money. Will wants to grow a garden so they don't have to buy so much food. Mae is thinking of setting up a recycling center in the kitchen. She recycles cans, bottles, and paper but doesn't know what to do with her plastic milk jugs. She thinks and thinks.

Will and Mae hear a knock at their door. They are greeted by Peter Plastic. He tells Will and Mae that he wants to be recycled. It took thousands and thousands of years to form the petroleum (oil) that plastics are made from, so why not recycle plastic milk jugs? Peter reminds Will and Mae that plastic milk jugs can be remolded into a variety of products like carpet and rope fibers, plastic lumber and shingles, and highway markers.

Scene III

Will and Mae are happy at last. They no longer have piles of trash. Once the trash was cleaned up, they began to see lots of ways to reduce the amount of trash they make. Mae decides to start buying in bulk and looking for items with less packaging and recyclable packaging.

They are joined on stage by Patty, Jill, Peter, and Al. They are now all happy that Patty, Jill, Peter, and Al are useful and valuable, and no longer just trash. They have made their world and ours a better place.

Mae and Will tell the kids about the local recycling options (or the need to take action to start recycling locally) and ask them to get their parents involved for the sake of Patty, Jill, Peter, and Al. Will and Mae remind everyone that we can all start reducing trash today!

(After the play, have the players discuss with the audience the concepts of waste reduction and recycling presented in the play. You may also want to open the floor for questions when presenting the play to younger audiences.)

The Business of Recycling

9.RE.7.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: Recycling markets.

Subjects: Social Studies, Economics,
Environmental Science

Materials: Copy of the South Carolina Recycling Markets Guide, call 1-800-SO USE IT to obtain a free copy

Teaching Time: One class period, plus research

Vocabulary: Recycled materials, the Center for Waste Minimization, Office of Solid Waste Reduction and Recycling



instead of virgin materials in their manufacturing processes. Others think that the government should leave finding markets for recycled goods to the normal business channels of supply and demand. The following quotes demonstrate different view points when it comes to recycling policies.

Learning Objective

Students will:

- research South Carolina's recycling markets
- consider ways to encourage recycling markets
- examine the economics of recycling from a business point of view.

Background

It's easy to say that everyone should be recycling. After all, recycling saves valuable resources and energy.

Beyond educating the public to the advantages of recycling at home, a critical component of recycling is finding markets for the collected materials. These markets are companies that are willing to buy the materials and reprocess them into new products.

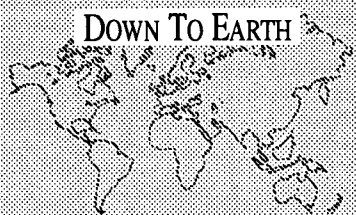
Some people think that the government should encourage recycling through policies that offer incentives such as tax advantages to companies that use **recycled materials**, materials collected to be reprocessed and used again to make new products,

“An inventory of the world's discards would reveal metals more valuable than the richest ores, paper representing millions of hectares of forests, and plastics incorporating highly refined petrochemicals. That these products rich in raw materials and concentrated energy are frequently considered worthless is indicative of a distorted economic system. We are literally throwing away our future.”

– These words written in 1987 by Cynthia Pollock-Shea reflect many people's views on the importance of recycling.

“We do not buy scrap out of altruism or patriotism. Neither do we buy it just because it saves energy or is good for the environment. It's nice if those benefits follow along but we don't have much patience with those who not only advocate, but would legislate, putting the cart before the horse.”

– a steel company executive made these comments in 1981 reflecting the bottom-line economics of recycling at the time.



The Japanese recycle about 45 percent of their used paper.

Source: EarthCare Paper Company

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According to *State Recycling Laws Update* newsletter (Feb. 1993), 39 states now have some sort of comprehensive recycling law that requires local governments to plan and reduce what's going into landfills and incinerators. Now the issue turns to "where are we going to sell all these segregated materials?" States have done a good job of mandating collection, but the markets have not magically appeared. Government and environmentalists claim the problem is that manufacturers have not moved to use recycled materials in their packaging and products. California, Oregon, and Wisconsin have mandates that require recycled content in packaging in rigid plastic containers although enforcement is nearly impossible.

Curbside recycling is popular, there are now more than 6,500 programs in the United States. Unfortunately, communities are not businesses and may not select the materials designated for pick-up and recycling based on local or regional markets. Materials are often selected based on a list mandated by the state, or are those that local politicians think are most problematic, or those that seem to have a high "weight" in landfills. In this country, business or commercial recyclers have few mandates, even though the economics are better.

While more and more businesses are looking at their waste streams and examining what they throw away, economics spurred by consumers dictate what they end up diverting from landfills.

The U.S. spent about \$315 million on recycling programs in the fiscal year 1991 - 1992.

In South Carolina, the Solid Waste Policy and Management Act of 1991 encourages recycling and buying recycled products. The Act mandates a 30 percent waste reduction by 1997.

The South Carolina Department of Health and Environmental Control (DHEC) works to help communities find markets for recycled materials and helps companies connect with local supplies of recycled materials through the **Center of Waste Minimization**. The South Carolina Department of Health and Environmental Control also provides

information on markets for recyclable materials through its **Office of Solid Waste Reduction and Recycling**. To receive more information, you can contact DHEC's Office of Solid Waste Reduction and Recycling at 1-800-SO-USE-IT. (NOTE: The binder for *Action for a cleaner tomorrow: A South Carolina Environmental Curriculum* is made from both pre- and post-consumer waste. See the back of the binder for specifics. The paper this curriculum is printed on is also a recycled stock. DHEC has a variety of items made from recycled materials, such as pencils and rulers, available for teachers.)

An annual guide to recycling markets and waste exchanges, *South Carolina Recycles Market Directory*, is printed and distributed statewide. The document lists markets for tires, lead-acid batteries, white goods (appliances), plastics, scrap metals, glass, paper, laser toner cartridges, textiles, pallets, drums, construction waste, photographic recovery, cooking oil, oil filters, oil absorbents, and used oil. For a copy, call DHEC at 1-800 SO USE IT.

Learning Procedure

1. **Ask:** Why isn't everyone recycling? Discuss the merits of recycling (*saves energy, saves resources, saves landfill space, reduces pollution, etc.*).

Ask: What is the difference between industrial recycling and household recycling? (*Industrial recycling takes place at the manufacturing site, recycling scrap materials and waste and using recycled materials in the manufacturing process instead of virgin materials. Household recycling is the pick-up or drop-off of household materials for recycling.*)

Ask: If recycling offers all these benefits, why is it sometimes said that recycling is not economically feasible? (*Some companies are not set up to use recycled materials and to do so would require expensive changes in manufacturing processes. In some cases, costs associated with handling and transporting recycled materials are cost prohibitive, raw materials are readily available for very low costs, some companies do not think that consumers are willing to accept higher prices for products that have recycled content, etc.*)

2. Divide students into small groups and assign each group a recyclable material to research. Have students report on the South Carolina markets for the recyclable.

For a more lengthy research project, have students investigate prices for the recyclable, where the materials are taken for reprocessing and what the materials become. Have students investigate household recycling and industrial recycling of the material. Students may want to write to several of the companies that use recycled materials instead of virgin materials to find out their reasons for doing so. This activity will take some time. Have students plan their research and schedule phone calls and letters to companies well in advance.

3. Tell the class that some people believe that the government should be involved in recycling and should make a National Recycling Policy that helps recycled materials compete. **Ask:** What do you think the government should do to help recycling? How should these projects be handled and funded?

Questions for the Class

1. Why is it important to know the markets available for a recyclable *before* you begin collection?

2. What is the difference between industrial recycling and household recycling?

Extension Activities

1. Have the class contact the National Recycling Coalition, (202) 625-6406, for their brochure promoting a national recycling policy. Conduct a poll of your class/school to determine if students favor governmental regulation of recycling. Let your representative know the results.

2. Have the class review South Carolina's Solid Waste Management Plan and report on the state's strategies for recycling. Invite a speaker from the Office of Solid Waste Reduction and Recycling or the Recycling Market Development Council to discuss the plan with the class and to answer questions. For a copy of the plan, write to: Department of Health and Environmental Control, Office of Solid Waste Reduction and Recycling, 2600 Bull Street, Columbia, South Carolina 29201.

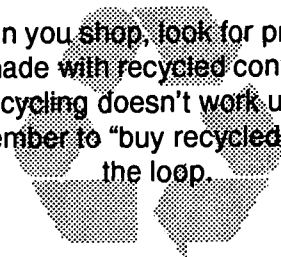
3. Have students investigate other states' recycling and environmental legislation and compare it to what's being done in South Carolina.

4. Have the class read the report *Canada Recycles* included with this lesson. Ask the class: Do you think this is a good strategy for the United States to follow?

5. If any of the companies listed in the *South Carolina Recycles Market Directory* are in your area, invite a speaker to visit your class to discuss operations or, if possible, schedule a field trip.

Just Do It

When you shop, look for products
made with recycled content.
Recycling doesn't work unless
we remember to "buy recycled" and close
the loop.



Canada Recycles

adapted from *State Recycling Laws Update*

Industry in the Canadian Province of Manitoba has agreed to support a comprehensive recycling program to the tune of \$10 million during the next three years through packaging assessments.

This is the first province to agree to the Canadian "packaging stewardship model" developed by the Grocery Product Manufacturers of Canada. The program is now called the Canadian Industry Packaging Stewardship Initiative (CIPSI) and supporters, about 20 organizations including grocery distributors and newspaper publishers have formed an organization, CISPO.

Under the concept, industry pays the difference between regular disposal costs and the extra cost to recycle used packaging in a "shared responsibility" program. Industry pays in to one national fund and these funds are used to assist in market development for materials. To make the plan work in Canada, provinces will have to issue what is called backdrop legislation, or laws that encourage companies to take part. Manitoba was the first province to agree. The province will issue new regulations that will require all manufacturers to either join the CISPO or pay a licensing fee to the province.

Manitoba already has a beverage container law requiring bottles and cans to meet recovery rates or face a tax of one cent each. Other laws are set to follow concerning other forms of packaging.

Initially, glass, steel, aluminum beverage, PET beverage, newspapers, and magazines will be included in collections for curbside and drop-off programs. The goal is to recover 75 percent. Other materials such as rigid and flexible plastic, boxboard, and composites will be added later as markets develop. Some Canadians believe that the program will not work unless Ontario and Quebec also sign on, because they represent 40 percent of the market, Manitoba represents just four percent.

The Ontario Recycling Council Director says the industry isn't offering enough money to make the system work in Ontario. The current Blue Box recycling program costs about \$100 million and some Ontario mayors are threatening to drop it. The director estimates that the cost of recycling over landfilling is about \$50 million per year.

Some people see a problem with the market development portion of the plan since most of Canada's packaging is imported from the U.S. Local recyclers would not be happy to see market development funds going to companies in the U.S.

The Canadian Institute for Environmental Law and Policy has drafted a policy paper. The report is expected to suggest Ontario enact a one-cent packaging tax as the alternative to industry paying in to the funding organization.

The debate over how to handle recycling in Canada is expected to continue with future legislation certain.

How Times Have Changed

9.LI.1.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: Population and waste management

Subjects: Social Studies, Environmental Science, History

Materials: *Sayings and Slogans* interview sheet, tape recorder (optional)

Teaching Time: Several class periods, plus home assignment

Vocabulary: Throwaway lifestyle, consuming

Learning Objective

Students will:

- interview parents, grandparents or other adults regarding their past lifestyles
- compare the waste management impacts of past and present lifestyles.

Background

In the past 30 years, South Carolina's population has grown from about 2.4 million (1960) to about 3.5 million in 1990. By the year 2010, South Carolina's population is projected to be about 4.5 million.

While South Carolina is still considered a rural state, population growth is an important factor in the state's solid waste management planning.

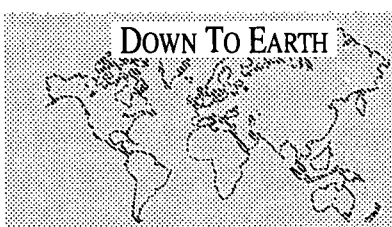
While the number of people living in this state is increasing, so is the amount of household or municipal solid waste that each person creates. In 1960, each person's share of South Carolina's municipal solid waste was 2.66 pounds per person per day. By 1990, this had grown to about 4.5 pounds per person per day, according to figures from the United States Environmental Protection



Agency. National numbers from the U.S. EPA were all that were available since, prior to the state's Solid Waste Policy and Management Act of 1991, there were no requirements to measure the amount of trash going to our municipal solid waste landfills. In 1995, South Carolina quantified its waste and figures and showed that, as an average, each person is responsible for generating 5.6 pounds of household garbage per day.

In addition to changes in the amount of solid waste generated in South Carolina and in the United States during the past 30 years, changes in technology, lifestyles, and the economy have resulted in changes in the composition of the nation's solid waste.

Today, we are used to **consuming** or buying and using, as much as we want and can afford as well as disposing of old items whenever we want new ones without considering the consequences of our actions. This "throwaway lifestyle" coupled with our growing population potentially threatens our environmental quality.



The average American uses nearly 12 pounds of HDPE (#2 plastic) bottles and containers in one year. This type of plastic makes up about 21 percent of the plastic in the municipal solid waste stream, although HDPE plastic is recyclable in many communities.

Source: *Waste Age* magazine

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PAGE
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Learning Procedure

1. Ask students to imagine themselves as reporters investigating how times have changed since their parent or grandparents were children. Read the following paragraphs to students:

“Toys have changed through the years. At one time, most toys were made of natural materials like wood. Then they were made of papier-mache, or were handmade country toys like whirligigs, bean shooters, yo-yos, jacks, and tops. Over time, commercially manufactured toys became available, like wooden Lincoln Logs and Tinker Toys and metal Erector Sets. Then plastic toys came on the market with Frisbees, Hula-Hoops, and plastic models. Now, battery-operated and electronic toys, pinball games, video games, and computers are popular.”

2. Ask students to respond to the following questions and encourage them to think of how their parents or grandparents might respond to the same questions.

- What were your favorite toys when you were a child? How many toys did you have?
- Of what were your toys made? Who made them?
- How long did your toys last? Could they be fixed if they broke?
- Would it have been cheaper to fix the toy or get a new one? Why? Could you fix a broken toy at home or did you take it somewhere else to be fixed?
- If broken toys could not be repaired, what did you do with them?
- How are toys sold today different from those you had when you were little?

3. Distribute copies of the *Sayings and Slogans* interview sheet. Review and discuss the sayings and what they mean. What other sayings come to mind?

4. As a homework assignment, instruct students to interview a parent, grandparent or other adult following the questions outlined on the sheet. *(Students may use a tape recorder to record interviews. Remind students that they must ask and*

have the permission of the person being interviewed before a tape recorder can be used.)

5. After interviews have been completed, have students share their results with the class. Discuss the terms “throwaway lifestyle” and “environmental quality” and conduct a classroom discussion addressing the following questions:

- How have lifestyles changed in the past 30 - 50 years?
- How have these lifestyle changes affected environmental quality?
- How can we change our present lifestyle to improve environmental quality?

Extension Activity

Have students research the term “planned obsolescence.” What does it mean? (*Planned obsolescence is when a product is intended to last a certain period of time and then be discarded, for example, many small household appliances have short product life expectancies.*)

Just Do It

Sure, our lifestyles and buying habits have changed, but you can *continue* to change!

Talk to your family about what you buy and teach everyone in your family to buy with the environment in mind.

SAYINGS AND SLOGANS

Part One

Sayings and slogans tell us a lot about the time in which we live. In the past, sayings like these mirrored the buying habits of the times:

“A stitch in time saves nine.”

“Waste not, want not.”

“An ounce of prevention is worth a pound of cure.”

“Built to last a life time.”

Today, we are more likely to hear:

“Quick and easy to use.”

“No mess, no bother.”

“Disposable.”

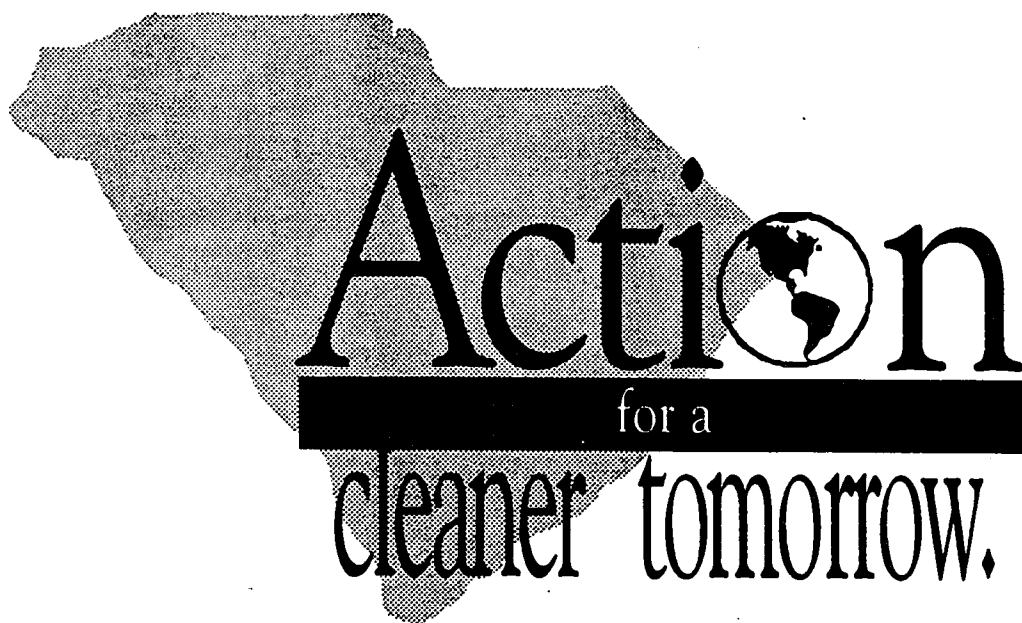
“Individually wrapped for your convenience.”

“They sure don’t make ‘em like they used to.”

Part Two

Interview Questions:

1. What other old sayings can you think of besides the ones here? What do the sayings mean?
2. What qualities in products did people appreciate when you were growing up? Has that changed over time? How?
3. Did people take better care of their belongings when you were growing up than they do now? Why?
4. How many pants, dresses, or pairs of shoes did you have?
5. When clothes wore thin or tore, were they repaired or were new ones purchased?
6. What did you do with old clothes? What did you do with old toys?
7. Can you show, or describe, a family heirloom and tell me the qualities that make it so special?
8. Do you think we are more wasteful today? In what ways? Why?
9. What types of things did you throw out in the trash when you were growing up? Were they similar to what we throw out today?
10. What containers did you use for trash? What did you do with the trash?
11. Did you have as much trash to throw away then as you do now? Why?



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

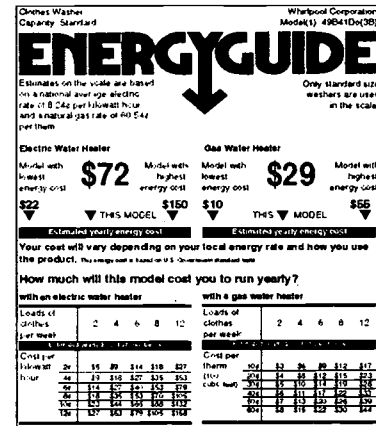
What It Really Costs

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9–12**Focus:** How the generation of waste materials may often be attributed to lack of insight of life cycle cost.**Subjects:** Environmental Science, Physical Science, Math (basic)**Materials:** *Life Cycle Cost* handout, Energy Rating Sheets from various appliances**Teaching Time:** One class period**Vocabulary:** Life cycle cost, kilowatthour

Learning Objective

Students will:

- determine the total cost of an item over its lifetime of expected use.

In this activity, students will calculate the comparative costs of size AA batteries that are commonly used items in the household. Students will then compare the actual lifetime costs versus the initial costs to compare the “best” buy. Students will relate this result to the savings in materials, energy, and landfill space.

Background

The idea behind **life cycle cost** is to calculate the entire cost of an item by using the *initial cost*, *expected lifetime*, and *cost of energy* used during the item's life-span. This is a concept not often understood by the public and not used in determining the overall cost of an item. For example, what is the best buy? Just the item that costs less to buy at the cash register or the item that costs less in the long run? All these factors, including costs of production, natural resources, and disposal costs are important when also looking at the impact upon the environment.

Learning Procedures

1. To help students understand the concept of “life cycle cost” have them complete the handout included with this lesson. The worksheet leads students through the process of calculating this value.

Costs for the items would include: cost of energy used, length of service life, initial cost of item to the consumer (the student).

Students may discover that the “best buy” is usually the best buy over time and that a product that is inexpensive to purchase often becomes the most expensive in the long term.

Also students will find that, through life cycle cost analysis, they can have an impact on the amount of materials used and discarded. An item that lasts longer may be more expensive initially, but is less expensive over the lifetime of the item. Buying less items means fewer materials in the waste stream. In many cases, such as batteries, there are also fewer items in the *toxic* waste stream.



A new robotic, solar-powered mower may be the answer to the U.S. EPA's announcement that all new, small, gas-powered engines will have to meet emission regulations after 1996. The initial cost, \$1,995, of a solar-powered mower may send people looking for old-fashioned push mowers instead.

Source: *Environment Magazine*

2. Use the appliance efficiency sheets (or permit students to visit an appliance store) and compare the energy efficiency labels on "white goods" appliances to discover the lifetime costs of: stoves, refrigerators, freezers, dryers, etc.

3. Have students consider their criteria for purchasing a car. How about a car's costs over time. Have students select a car they'd like to have and find out the initial cost of the car, fuel efficiency or miles per gallon, and anticipated cost of gasoline required to drive the vehicle during its life expectancy. (You may set these for the class. The average car is driven about 10,000 miles per year. Most cars will last at least 10 years.) Have students share their results with the class.

\$_____ price of car initially

_____ average miles per gallon

x 10,000 miles per year x _____ (life expectancy or 10 years)

Remind students that this does not take into account the costs of repairs or how proper maintenance can extend the life of a car. It does give an idea of how energy consumption can effect the overall cost of an item.

Questions for the Class

1. What factors must be considered when calculating life cycle costs?

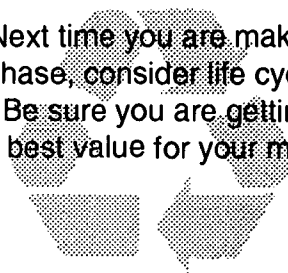
2. You are comparing two electric ranges to purchase. Range A costs \$624 and uses 40 kilowatthours (KWH) per month. Range B costs \$407 and uses 69 KWH per month. Calculate the life cycle costs for each and determine the best buy. You can consult your electric bill or contact your local power company to learn the cost per KWH in your area. (Or use the national average electric rate of \$0.0825 per kilowatthour.)

3. Refrigerator A costs \$919 and uses 587 KWH per month. Refrigerator B costs \$1,700 and uses 152 KWH per month. Calculate lifetime costs for both appliances and determine the best buy.

4. Electric water heater A costs \$198 and uses 3240 KWH per month to operate. It has a service life of 15 years. Electric water heater B costs \$577 and uses 1200 KWH per month. It has a service life of 15 years. Calculate lifetime costs and determine the best buy.

Just Do It

Next time you are making
a purchase, consider life cycle costs.
Be sure you are getting
the best value for your money.



LIFE CYCLE COST

Example

DISPOSABLE VERSUS RECHARGEABLE BATTERIES

Service Life for the following:

AA Alkaline

Battery Type
**Rechargeable
Batteries****Disposable
Batteries**How Long They Last

4 hrs. per charge - 9 hrs. service life
 service life worth up
 to 1,000 charges = 4,000 hrs.

Original Cost
\$5.95Original Cost
\$1.40Total CostTotal CostCost of Charger & Batteries
\$13.95 divided by 4,000 hrs.Cost of Batteries
\$1.40 divided by 9

\$.005/hr
 (Plus nominal electric power)

\$.16/hr

Type:

A

B

How Long They Last

Original Cost

Energy Cost

_____ per kilowatthours per month x 12 x _____
 years service = Total Energy Used

Total Energy Used x \$.0825 = Energy Cost
 Energy Cost + Initial Cost = Total Cost

ENERGY TECHNOLOGY LIFE CYCLE COSTING

Service life for the following appliances:

Freezer	20 year service life
Refrigerator	15 year service life
Gas Range	13 year service life
Electric Range	12 year service life
Dishwasher	11 year service life
Clothes Washer	11 year service life
Electric Dryer	14 year service life
Gas Dryer	13 year service life

Use the EnergyGuide for the dishwasher to answer
 the following questions:

1. Why is there one estimate for yearly energy costs for \$58 and another one for \$35?
2. What was the cost per kilowatthour and about how many loads of dishes per week was used to obtain the estimate of \$58?

Do you think the estimate for \$58 is too low or too high? Explain your answer.

3. Using the chart at the bottom of the EnergyGuide, determine how much the yearly energy cost would be if you washed 6 loads of dishes per week and used an electric water heater. (Use approximate cost/kilowatthour for our area.)

Use the EnergyGuide for the clothes washer to answer the following:

4. What is the difference in the average estimated yearly costs of using electricity vs. gas?
5. What is the estimated yearly cost of the electric washer with the lowest energy cost?

What is the estimated yearly cost of the electric washer with the highest energy cost?

6. Using the chart at the bottom of the EnergyGuide, about how much would an electric washer cost per year if you wash 4 loads of clothes each week?

Sample Energy Rating Sheet

Clothes Washer
Capacity: Standard

Whirlpool Corporation
Model(s): 49B41Do(3B)

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 8.24¢ per kilowatt hour and a natural gas rate of 60.54¢ per therm.

Only standard size washers are used in the scale.

Electric Water Heater

Model with lowest energy cost

\$72

Model with highest energy cost

\$150

Gas Water Heater

Model with lowest energy cost

\$29

Model with highest energy cost

\$55

▼ THIS MODEL ▼

▼ THIS MODEL ▼

Estimated yearly energy cost

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests.

How much will this model cost you to run yearly?

with an electric water heater

Loads of clothes per week	2 4 6 8 12					
Estimated yearly \$ cost shown below						
Cost per kilowatt hour	2¢	\$5	\$9	\$14	\$18	\$27
	4¢	\$9	\$18	\$27	\$35	\$53
	6¢	\$14	\$27	\$40	\$53	\$79
	8¢	\$18	\$35	\$53	\$70	\$105
	10¢	\$23	\$44	\$66	\$88	\$132
	12¢	\$27	\$53	\$79	\$105	\$158

with a gas water heater

Loads of clothes per week		2	4	6	8	12
Estimated yearly \$ cost shown below						
Cost per therm (100 cubic feet)	10¢	\$3	\$6	\$9	\$12	\$17
	20¢	\$4	\$8	\$12	\$15	\$23
	30¢	\$5	\$10	\$14	\$19	\$28
	40¢	\$6	\$11	\$17	\$22	\$33
	50¢	\$7	\$13	\$20	\$26	\$39
	60¢	\$8	\$15	\$22	\$30	\$44

Dishwasher
Capacity: Standard

Whirlpool Corporation
Models: All Models

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 8.30¢ per kilowatt hour and a natural gas rate of 59.46¢ per therm.

Only standard size dishwashers are used in the scale.

Electric Water Heater

Model with lowest energy cost

\$58

Model with highest energy cost

\$89

Gas Water Heater

Model with lowest energy cost

\$35

Model with highest energy cost

\$47

▼ THIS MODEL ▼

▼ THIS MODEL ▼

Estimated yearly energy cost

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests.

How much will this model cost you to run yearly?

with an electric water heater

Loads of dishes per week		2	4	6	8	12
Estimated yearly \$ cost shown below						
Cost per kilowatt hour	2¢	\$5	\$9	\$14	\$18	\$27
	4¢	\$9	\$18	\$27	\$36	\$54
	6¢	\$14	\$27	\$41	\$54	\$81
	8¢	\$18	\$36	\$54	\$72	\$108
	10¢	\$23	\$45	\$68	\$90	\$135
	12¢	\$27	\$54	\$81	\$108	\$163

with a gas water heater

Loads of dishes per week	2 4 6 8 12					
Estimated yearly \$ cost shown below						
Cost per therm (100 cubic feet)	10¢	\$8	\$18	\$25	\$33	\$49
	20¢	\$9	\$18	\$27	\$35	\$53
	30¢	\$9	\$19	\$28	\$38	\$57
	40¢	\$10	\$20	\$30	\$40	\$61
	50¢	\$11	\$21	\$32	\$43	\$64
	60¢	\$11	\$23	\$34	\$45	\$68

Thermodynamics, Litter & Resource Recovery

9.3R.7.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 10 – 12

Focus: Resource recovery, litter, source separation

Subjects: Physical Science, Social Studies, Physics, Math

Materials: Deck of cards, food coloring and bowl of water, golf or ping pong balls, sheets of paper cut into pieces with plastic coding symbols drawn on them, colored beads

Teaching Time: Two class periods

Vocabulary: Thermodynamics, entropy

Learning Procedure

Ask if anyone in the class knows the definition of the term thermodynamics. Explain that **thermodynamics** is the physics of the relationships (dynamics) between heat (thermo) and other forms of energy. Demonstrate for the class or have students participate in teams in demonstrating these exercises.

1. Starting with a deck of cards ordered by suit, shuffle the cards. Observe. Then shuffle again. How long will you have to shuffle until the cards are in order again?

2. Drop some food coloring into a bowl of water. Describe what happens to the food coloring and discuss what would be necessary to reconcentrate the food coloring.

3. Scatter golf or ping pong balls from an ordered position. How much energy does it take to reorder the system?

4. (Before class begins, take about 20 pieces of paper [or index cards] and on each piece draw one of the plastic coding symbols, number one through seven. These pieces of paper represent the various types of plastic we use and then recycle, reuse, or throw away.) Stack these pieces by code on your desk. There should be several of each type. Push the pieces of paper off your desk. Using time as a measurement, compare the amount of energy it takes to reorder the system so that the number one and number two plastics can be recycled without contamination from the other types.



Learning Objective

Students will:

- become familiar with the Second Law of Thermodynamics, which states that any system and its surroundings tend spontaneously toward a state of increasing disorder; in other words, **entropy**.
- see a littered school ground and garbage that has been dumped together as disordered systems.
- understand that some resource recovery processes are energy and time-intensive methods of trying to bring order to this system.

Background

As much as 49 percent of litter materials are made from recyclable items and it costs about one dollar per pound to pick up litter.

The Second Law of Thermodynamics states: Without a constant input of energy, all systems and their surroundings tend toward disorder. A discussion of littering, landfills and resource recovery can graphically illustrate this law.



The United States – and South Carolina – have a recycling goal of 25 percent. California and some other states are creating special enterprise zones that provide tax breaks and other incentives to new firms handling a recycled material.

Source: 1994 Environmental Almanac

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5. Use beads of various colors to represent natural resources – aluminum, tin, petroleum (plastics), wood – that commonly end up as solid waste. Put each color group in a different cup. Dump beads from separate cups together to represent mixed garbage; then, using time as a measure, compare the amount of energy needed to separate the beads and reorder the system. Have students make a chart to compare how long it takes to mix up the items versus how long it takes to reorder them.

6. Go outside and observe areas of your school that are badly littered. Discuss:

- Whether it takes more energy to dispose of litter properly in the first place or to reorder the system, (i.e., have custodians pick it up). The people who have to spend their time picking up the litter could be using their time and energy more constructively.
- Whether the amount of litter is acceptable or not and why it is there. **Ask:** What are some of the possible solutions to help with the problems of school litter?

7. When it comes to solid waste, discuss why a landfill is a good example of a disordered system.

Ask: Before the garbage ends up in the landfill, how could this “system” be reordered? (*limit consumption, source separate, and recycle*)

Ask: Why are attempts to reorder the system after the garbage is mixed together (i.e., some resource recovery processes attempt to sort the garbage after it has been collected, this is called commingled recycling) much more energy-intensive and expensive than source separation? Can you think of situations where commingled recycling might be effective? (*Where there is a source of very inexpensive labor to do the sorting, such as prison labor.*)

8. Create a step-by-step system for solid waste disposal from generation to final disposal that is more efficient than the current system. Outline the energy-saving components of your system.

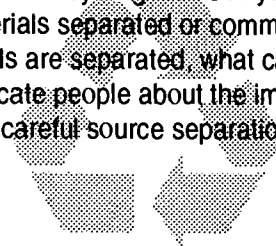
Extension Activity

Research and discuss the net energy inputs and outputs of various energy sources: natural gas, gasoline, ethanol, methanol, electric batteries, hydroelectricity, solar power, and wind power.

For example, how much energy does it take to harvest the raw material and refine it into a useful energy source versus how much of this energy could be converted into other energy sources? What are the net energy inputs into collecting raw crude oil and refining it into gasoline versus the net energy output of gasoline in terms of converting the stored energy of gasoline into the mechanical energy of making a car move?

Just Do It

Find out how recycling works in your area. Are materials separated or commingled? If materials are separated, what can you do to help educate people about the importance of careful source separation?



Generating Methane from Waste

9.3R.8.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

Focus: Recovering energy from waste

Subjects: Environmental Science, Chemistry

Materials: See list of materials itemized below

Teaching Time: One class to set up the experiment, time for generating gas will depend upon procedure used.

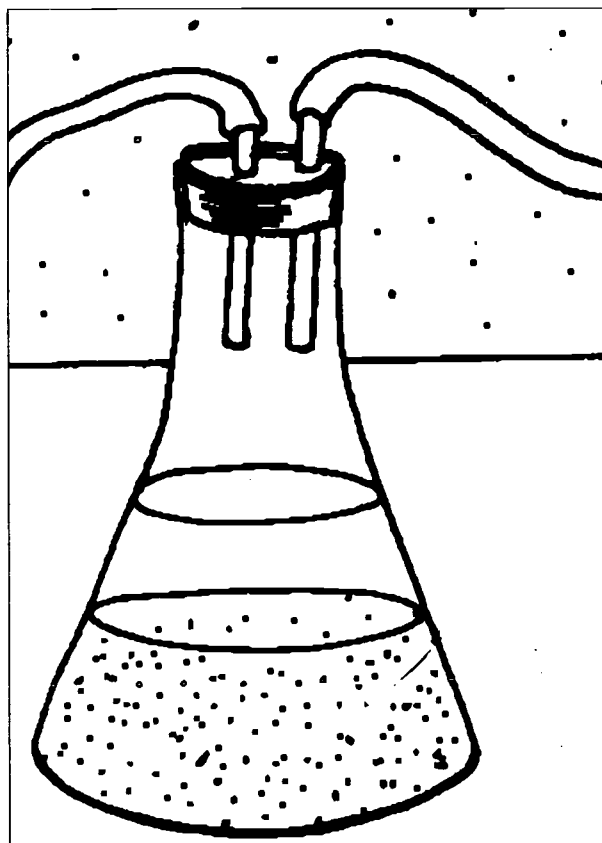
Vocabulary: organic waste, methane, slurry, anaerobic, pyrolysis, methane digester

Note: This experiment may be used as a demonstration during the study of decomposition and composting. Generating gas may take several days.

Learning Objective

Students will:

- understand the energy-producing potential of some solid wastes
- examine some systems of generating methane from waste
- construct a model methane generator.



Background

Methane gas is created naturally as a waste product of anaerobic bacteria living in water-logged soils and wetlands, and also in human-produced environments such as rice paddies and landfills. The digestive system of animals such as cattle and sheep contain these bacteria and produce methane gas. A single cow belches out 100 gallons of methane each day. The microbes in the guts of termites, which digest wood, also produce methane. Methane is produced for fuel in some parts of the world and burned in **methane digesters**. Methane gas is a greenhouse gas and contributes to global warming. About 12 percent of global warming is attributed to increases in methane in the environment.

The top ten sources of methane in our atmosphere:

1. wetlands	20.2%
2. rice fields	19.4%
3. cud-chewing animals	14.0%
4. biomass fires	
such as burning forests	9.7%
5. oil & natural	
gas pipeline leaks	7.9%
6. termites	7.0%
7. coal mining	6.2%
8. landfills	6.2%
9. animal wastes	5.0%
10. sewage	4.4%

(Source: *Environmental Literacy, the A to Z Guide*)

In China and India, there are millions of mini-power plants that use methane gas.

Source: *Environmental Literacy, the A to Z Guide*

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Once buried, **organic wastes** decompose **anaerobically**, which means that they decompose without oxygen. **Pyrolysis** is the chemical change as a result of an increase in temperature that produces heat. Carbon dioxide, methane, ammonia, and hydrogen sulfide gases are all produced as microorganisms break down waste. Note this distinction. This lesson deals with organic wastes. Inorganic wastes *may* decompose eventually, if given enough oxygen, light, and time. However, they do not decompose in a landfill where they are sealed off from oxygen and light.

Trapped beneath the landfill surface, the gas byproducts of organic waste decomposition become potential health and safety threats if not properly vented. To avoid explosions or lateral migration of methane beneath the surface of the landfill, vents are installed to reduce pressure build-up of the gases.

Methane is the largest component of natural gas. If the landfill volume is great enough (at least one million tons), the methane produced can be captured, purified by removing carbon dioxide and water, and sold to gas utility suppliers. Capturing methane from landfills may not turn a profit, but it can help to defray the landfill's operating costs. There are many methane recovery systems operating or under construction in the United States, and a great many more landfills large enough to handle a methane recovery system.

In South Carolina the Lexington County Landfill recovers methane that is piped to the Gaston Copper & Asphalt plant across the street from the landfill. The Aiken County Landfill has a similar recovery system in place with methane piped to the Clay Mine next door.

According to an article in *Waste Age* magazine, "The Clean Air Act," November 1993, the United States EPA has proposed new performance standards for new municipal solid waste landfills and emission guidelines for existing facilities under Section 111(b) of the Clean Air Act. This was in response to EPA's findings that municipal solid waste landfills can be a major source of air pollution

that contribute to ozone problems, air toxics concerns, global warming, and potential explosion hazards.

The EPA conducted a study of landfills to determine the methane generation rate constant and the potential methane generation capacity of the refuse. Based on this data and other assumptions, EPA estimated that the baseline (1987) emissions from the 7,124 existing landfills in the U.S. was 15 million mg/yr of methane and 300,000 mg/yr of other non-organic compounds that occur in landfill gas including trichlorofluoromethane, trichloroethylene, benzene, vinyl chloride, toluene, and perchloroethylene. These predictions do not include emissions from the some 32,000 landfills closed prior to 1987.

Because of emissions concerns, EPA is considering the regulation of "municipal landfill gas emissions" in total.

Materials

- safety glasses
- fume hood (if using heat source)
- three Earlenmyer flasks (one 500 ml, two 125 ml)
- a lubricant such as petroleum jelly
- organic slurry of manure or ground grass clippings, etc. (from a compost pile)
- balloon (blow it up several times to stretch it out, this makes it easier to inflate)
- three rubber stoppers (these may be pre-drilled)
- one foot of glass tubing
- 3 feet of surgical tubing (or any flexible tubing that can be attached to glass tubing)
- the nozzle from a medicine dropper
- one pinch clamp
- a drill to bore a hole in rubber stopper (you may have pre-drilled stoppers)

Learning Procedure

I. Review with the class the background material included with this lesson. Explain to students that they are going to create a methane generator.

2. Refer to the illustration to help with setting up the methane generation/collection apparatus. Wear safety goggles. This experiment must be properly constructed. Your system must be well-sealed. Any leaks will result in a lack of gas pressure. *(You will want to practice this experiment and have students assist you in demonstrating the experiment for the class, if enough equipment is available, you may have students set up several stations.)*

3. Wear safety goggles while setting up and conducting this experiment. Bore two holes in each rubber stopper, or use a stopper with two holes already in place.

4. Run a tube from the flask representing the landfill to a gas storage container. *(NOTE: Make sure all connections are tight. Use petroleum jelly or Amogel on stopper holes. Keep tubing to a minimum. Use large diameter tubing.)* The storage container's stopper should have two holes, one for the tube coming from the landfill flask (the large flask) and one for a nozzle and clamp — this is your flare.

5. Run a tube from the large flask representing the landfill flask to the third flask. This is the pressure relief system. Attach a second tube to the third flask and connect a balloon that's been blown up several times. Make sure the tube from the landfill flask extends down into water (see illustration, fill your gas collecting flasks to near capacity with water). This arrangement will prevent an excess of gas from feeding back into the landfill flask.

6. Fill the large flask about three-fourths full with an organic slurry (*i.e. manure and ground grass clippings, etc. mixed with water until a thick, but pourable, consistency is reached*). This flask will represent the landfill. Keep it warm. In the classroom, keep it away from any air conditioning. Warmth from a sunny window will help. You may keep this set up under a fume hood.

7. It will take days, maybe even weeks before gas is produced. Keeping the slurry warm speeds production. As gas is produced, the balloon is inflated.

Optional Procedure to Speed Up Gas Production

1. Set up as before only without the second flask, which involved the flare.

2. Let the slurry (compost and manure) set overnight and then apply continuous heat and stirring. (Use a hot plate set on about 3 or 4.) This should produce gas in about 20 minutes. You should see the balloon inflate.

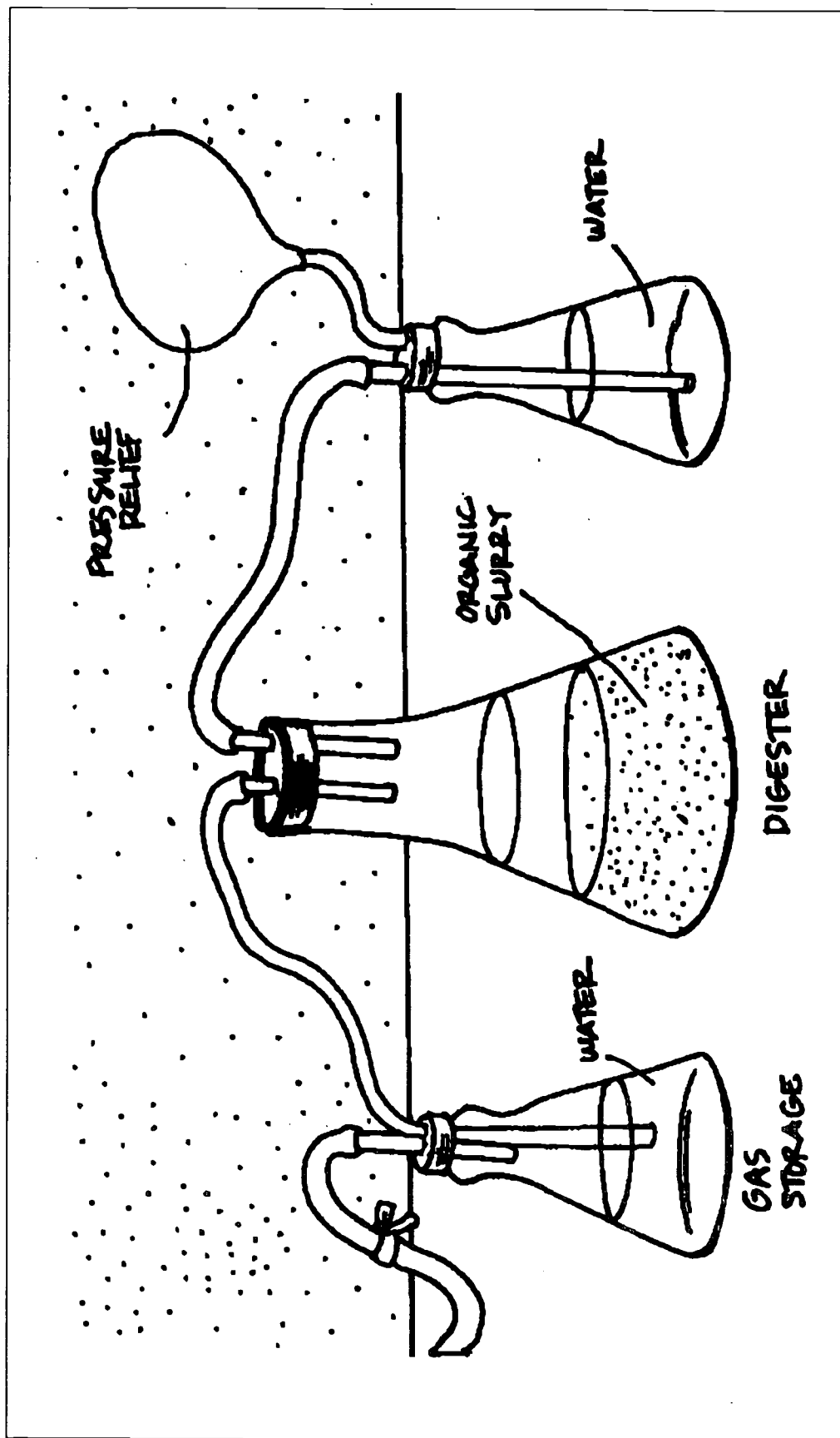
Questions for the Class

1. What is methane?
2. How is it produced?
3. List materials that can be used to generate methane.
4. Describe another means of using solid waste to produce fuel.

Extension Activities

1. Have students research the historical uses of methane gas digesters. For example, in Holland a tarp was placed over a portion of a swamp with a hose running from under the tarp to the house for light and heat.
2. Have students work in teams to build four or five of these three-flask methane generation/capture apparatuses. Have students test different organic wastes. Which produces the most gas the fastest? Which waste produces the best fuel?
3. Research modern methane technology.
4. Study resource recovery technology to learn how industrial fuel is created from solid waste by pyrolysis.

Methane Digester Model



Spreading the Word About Sludge

9.3R.9.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: How sewage sludge and manure can be applied to the land to reduce solid waste and return nutrients to the earth.

Subjects: Social Studies, Science

Materials: This is a reading, research, and interview activity

Teaching Time: One class period presentation plus research

Vocabulary: Composting, sewage sludge, dewatered

Learning Objective

Students will:

- determine the benefits and drawbacks of land application of sewage sludge
- gather information on quantities and methods of sludge disposal in their communities.

Background

- excerpted from an article entitled "Sludge," by David Tenebaum in the Oct./Nov. '92 issue of *Garbage* magazine.

One large component of the waste we produce daily is our bodily waste. Because of modern plumbing and septic systems, we are able to flush away and forget this waste. However, each time we flush a toilet, we typically send about five gallons of clean water, as well as matter full of minerals and nutrients, down the drain. Both water and rich organic matter are wasted.

Of the 25 billion gallons of **sewage sludge** produced daily in the U.S., 15 percent goes into the ocean, 35 percent is burned, 25 percent is buried,

and the remaining 25 percent is composted. Many South Carolina residences use household septic tanks – leach field systems, to treat their septic wastes. Other on-site treatment includes dry wells, outhouses, and composting toilets.

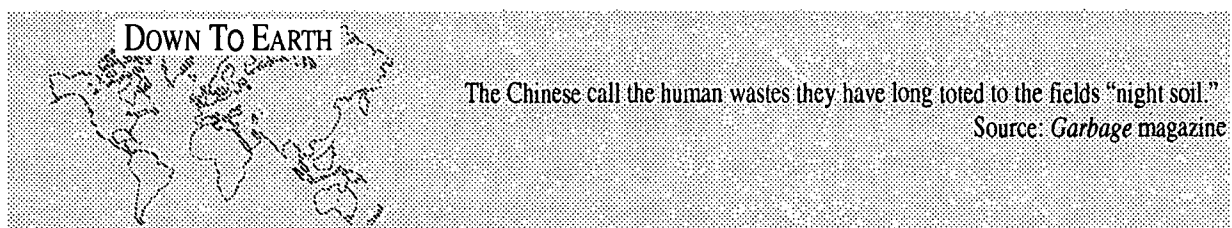
The remaining households in South Carolina make use of one of the 262 municipal and 1,056 non-municipal sewage treatment plants, and 67 drinking water treatment plants. Various industrial activities such as papermaking also generate sludge requiring treatment and disposal.

Sewage can be processed and used as soil conditioner, an option more communities are investigating in order to save disposal costs.

Sewage sludge is **dewatered** and composted to produce soil conditioner or fill. Once sterilized, the material can be used as fill in landfills or spread on fields. Treated sludge is mainly used as a food for feed crops and ornamentals, not for feeding the crops that feed people.

Spreading sludge on land maximizes its soil-enriching value.

Septic sludge is an entirely different issue from sewage sludge. Septic sludge, that is sludge from septic tanks, contains pathogenic (disease-causing) bacteria, viruses and other microorganisms from human wastes. Soil conditioners made from septic wastes fed with commercial industrial waste are often contaminated with heavy metals such as cadmium, mercury, as well as pesticides. There is differing opinion as to whether sludge and/or compost from this kind of sludge poses a health threat.



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[NOTE: According to South Carolina's Department of Health and Environmental Control, waste water-treated sludge should not contain pathogens. For the purposes of this lesson, this article discusses the benefits of sewage sludge.]

Treated or **composted** sludge can be packaged and sold as organic fertilizer. Products made in this way include Nu-Earth from Chicago, Milorganite from Milwaukee, ORGRO from Schenectady, and Metroloam from Boston.

[In South Carolina, the Department of Health and Environmental Control regulates which plants can receive sludge.]

According to *Garbage* magazine, "Sludge," October/November 1992, treated sludge is benign smelling, and is quietly becoming a big recycling success story.

By putting sewage sludge on farm fields, we're closing a major resource loop – from farm crop to food to sewage to sludge to fertilizer back to farm crops.

As recently as 1982, 75 percent of this waste was buried in landfills, abandoned in giant lagoons, dumped in the ocean, or incinerated.

Recycling has been pushed by the need to do something with the 6.1 million dry tons of sewage sludge produced by the United States each year.

Today, most of our recycled sludge – 42 percent of total production – is applied to farms, forests, and degraded land. Another 5.8 percent is bagged and sold or given to landscapers, highway departments, and consumers.

When you compare sludge's 48 percent recycling rate to the 13.3 percent of household solid waste that's recycled, and when you consider that some solid waste "recycling" is just junk material awaiting a market, you can see why some consider sludge one of this country's premier recycling successes.

But, half of the nation's sludge still gets dumped. With the right processing, this waste can be diverted from landfills and recycled into farm fields.

Slogging into Sludge

Sludge, a residue of the solid portion of municipal wastewater, is produced at a sewage-treatment plant. Like most such plants, the one in Madison, Wisconsin, is adjacent to a wetland. (Sewage plants are located as low as possible so gravity helps wastewater flow toward them.) At the plant, a series of fetid "swimming pools" and white domes – both housing various treatment processes – announce the presence of "Microbes at Work." Underground is a web of gargantuan pipes and pumps.

Wastewater arrives via an intake pipe that spews forth a gray soup of ingredients like water, urine, feces, intestinal bacteria, toothpaste, shampoo, paint, cleaners, and whatever else we pour down the drain. A good treatment plant separates this slurry into fairly clear water and clean sludge. Briefly, here's how:

When the "soup" arrives, gravel, and sand settle out and scum is skimmed from the surface. Then water and the "heavy materials" start going their separate ways. The primary sludge enters huge, bubbly tanks, where oxygen-loving (aerobic) bacteria feast on organic matter.

Next it's piped to oxygenless "digesters" where anaerobic bugs devour stinky, ammonia-rich organic matter. (The methane that's released is burned for electricity to power Madison's plant.)

After about 20 days in the anaerobic digesters, the sludge is stabilized, the odor is gone, and the nitrogen has been transformed into nitrates (NO_3), a plant fertilizer. Although heat and chemicals inside the digesters kill most of the nasty bacteria.

"In all the years that sludge has been put on agricultural land, there's not been a [single] documented case where someone has developed an infection due to land application," says Art Peterson, a veteran sludge scientist.

After the winter's freeze out, when the soil is thawed, tankers truck liquid sludge over the short haul to nearby farmland. (To cut transportation costs, some plants dry their sludge.) In the fields, specialized tanker-tractors weighing 50,000 pounds (fully loaded) gulp down 3,500 gallons at a serving, and inject the liquid about eight inches into the soil. The applicator injects roughly 12,000 gallons to each of the eight to 10 acres it covers each day.

If you were to drive past a field that's freshly treated with sludge, you wouldn't notice much more than dark, moist soil. Take a whiff and you'd get an earthy aroma, similar to compost. Because of the sewage district's attention to detail, you wouldn't notice any of the black slurry.

Growing plants, however, get a good dollop of what Art Peterson calls "black gold." Experiments show that sludge can entirely replace commercial fertilizer on field corn (corn grown for cattle and hog feed). Unlike chemical fertilizers, humus-heavy sludge improves soil structure, thereby increasing water infiltration and decreasing runoff.

Publicity is critical to sludge-recycling programs. When the Madison district began spreading sludge in 1974, "recycling" was just entering common parlance, and nobody was sure how local farmers would react to a black slurry from a sewage plant.

A new name was key to Madison's PR program. "Sewage sludge evokes very negative images," understates recycling program director David Taylor. So the district held a contest for a euphemism and applied the winner, "Metrogro," to Madison's processed sludge. The district emblazoned the flashy name on its stainless-steel tankers, which are considerably cleaner than the semis now unloading at your supermarket.

The name game is catching on nationally. In December 1990, a professional group called the Water Environment Federation sponsored a national competition for a moniker less fearsome than "sewage sludge." Are you ready for "biosolids?" Researchers for Webster's have opened a file on "biosolids" for possible incorporation in a future edition.

In Madison, at least, the PR campaign worked. The district hauls about 10,000 tons of dry solids per year, enough to cover about 4,000 acres. Farmers want more. Taken together, they've put up about 30,000 acres for treatment. Those who are lucky enough to do a deal for Metrogro aren't altruistic recyclers: Farmers get all the nitrogen and phosphorus they need for field corn at just \$7.50 an acre. If purchased in chemical fertilizer, these elements would cost roughly \$40 per acre per year. (A sludge farmer might need about \$10 for additional potassium.)

The big picture: According to soil scientist Art Peterson, one to two percent of the nation's cropland — much of which has been depleted by erosion or chemical-intensive agriculture — could absorb the entire national output of sludge. And a minor irony: If sludge recycling catches on, it will transform the kitchen garbage disposal from its perch on the acme of superfluous gadgetry to a recycling highway. Instead of schlepping orange rinds and coffee grounds to the compost heap, we would sluice them down the drain and hit the disposal switch. The sewage-treatment plant will do the rest. (Of course, by circumventing the compost pile, you'll miss out on a valuable soil amendment for your backyard.) *[In South Carolina, neighbors are notified of sludge usage at neighboring farms and can request a public hearing.]*

Dealing with Pollutants

What about all the household and industrial toxics that are flushed down drains, to join the 40 million gallons of wastewater that flows daily into Madison's treatment plant? What about pathogens and parasites?

With sewage treatment, much of the incoming slop decomposes into benign substances. Take glucose from food, which if left untreated would travel with wastewater into lakes and rivers, depleting oxygen. At the sewage plant, incoming glucose is broken down by microbes into carbon dioxide and water. But some components, like heavy metals and PCBs, do remain intact.

To appreciate the hazards of accepting polluted wastewater, the Madison district need look no further

than the lagoons where it still stores sludge that accumulated for three decades before recycling began in 1974. Those lagoons are so polluted with cancer-causing PCBs that Madison became the nation's first sewage district to be placed on the federal Superfund list for cleaning up hazardous waste sites. The district may be compelled to burn millions of gallons of contaminated sludge at a cost of \$50 million to \$100 million. "Whether your standards are financial or environmental, it's a hideous prospect," says chief engineer James Nemke.

The lesson is simple: Once heavy metals, chemical pesticides, or other nasties flow into the waste stream, it's very tough to get them out. That's why the district requires industries to pretreat their sewage. Some manufacturers in the Madison district have substituted less-toxic materials, thereby cutting toxic effluent. Others use precipitation to remove heavy metals from effluent. (Precipitation converts a toxic material from a soluble to an insoluble form, which settles out of wastewater.)

Nationwide, metal concentrations in sludge are also falling, a reflection of the recycling imperative. In the mid-1970s, battery, plastics, and electroplating industries upped the cadmium level in Chicago's sludge to 280 to 300 parts per million (ppm). By 1992, those numbers fell to 40 ppm — much of it from background sources such as tire particles flushed down street sewers.

Quality control in Madison and elsewhere is ensured by a network of tests and government regulations. Each day, newly processed sludge is analyzed for total solids and nitrogen content. Each month, the district checks for phosphorous, potassium, cadmium, and other metals. Every other month, it looks for 39 more metals, pesticides, herbicides, PCBs, and bacteria.

Madison tests the surface layer of sludge-treated soil at least once every three years. (Because heavy metals are much more mobile in acidic soil, sludge-treated fields must be maintained at a pH of 6.5 or higher.) Deeper soil samples and plant tissues are analyzed for cadmium, copper, lead, nickel, and zinc. Before and

after each application, the district tests more than 750 private wells for their pH, as well as zinc and nitrate. One significant change has been detected: an increase in nitrate levels. Credit wider use of nitrogen-heavy commercial fertilizers.

PCBs? These cancer-causing compounds bind tightly to sludge and degrade extremely slowly. The federal maximum of PCBs in sludge intended for land application is 50 ppm. In 1991, Madison's sludge averaged 5.5 ppm.

Despite the concern about heavy metals in sludge, they too tend to stay where they are, as long as the soil isn't too acidic (above pH 6.5). In 1986, Art Peterson tested heavy-metal levels in sludge for the Milwaukee sewer district. He concludes, "Movement of these metals into groundwater seems practically impossible." As for crops grown from sludge-treated soil, when Mr. Peterson tested corn he found lead levels were below the detection limit of 1 ppm.

Pathogens? Most are killed by chemicals and heat in a treatment plant's anaerobic digester. To prevent the survivors from being eaten by those on top of the food chain (you and me), sludge is kept out of the vegetable patch. Feed crops that receive sludge are dried, ground, and eaten by animals, significantly cutting a disease-causing organism's chances of finding its way to us.

Healing the Land

In Central Illinois, where farms are measured in thousands of acres, human waste is repairing a human wasteland. Following World War II, in this farmscape: 200 miles southwest of Chicago, strip miners cast aside dozens of feet of "overburden" from entire square miles — all in pursuit of a four-foot thick seam of coal. After the mining companies ripped out the coal, they left behind a scarred landscape with inexplicable hills and odd-shaped lakes covering nearly 16 square miles. Nobody seemed to care that the "overburden" comprised some of the world's most productive farmland.

On 345 acres of tailings piles, nothing grows: no trees, no grasses, no shrubs. These enormous mounds of subsoil, rock, and low-grade coal were left by miners

when they departed more than 30 years ago. With a pH less than 3, not even soil bacteria tolerate the highly acidic piles. Attempts to reclaim tailings piles with chemical fertilizer have failed, partly because there's no organic matter to support essential soil microorganisms.

But Chicago's Water Reclamation District is working a miracle. The refuse piles are springing back to life. And they are being served generous dollops of sludge.

It's not a pretty process: scalping the bizarre hills left by strip miners into an erosion-resistant landscape, then covering them with thousands of tons of black sludge. But it works. Each acre of the district's largest pile, which covers 110 acres to about 50 feet deep, was covered this past summer with 1,000 dry tons of sludge and 70 tons of agricultural lime. Test plots, begun in 1987 on similar tailings piles, have shown that plants flourish once sludge restores organic matter and neutralizes the acid. The reclaimed refuse piles are now capped with a crop of grasses and legumes — feeding grounds for songbirds and small mammals.

An imperfect miracle, but a miracle nonetheless. To my eye, this piece of planet Earth is far more healthy than it's been for decades. All thanks to sludge.

Learning Procedure

1. **Ask:** We tend to focus our attention on the waste from manufacturers and households, but what do you think happens to the *human waste* we flush away every day? (List student responses on the board.)

Explain to students that human wastes often end up in incinerators, in the ocean, or in landfills and that proper management of these wastes is important to our environment.

2. Review with the class the Background information. Tell students that they are going to be conducting research about their community to find out what is happening to wastes.

3. As a class or in project teams, contact sewage treatment plant operators and sanitary engineers in your community and find out what is happening to sludge. Is it being recycled? Taken to local landfills? Burned? If sludge is recycled, is it made available to farmers, landscapers, or the public? How is the recycled sludge being used?

4. Interview farmers or gardeners who use sludge and ask about the use of sludge as a soil enhancer.


5. Have students prepare a booklet for your school library on your community and its sewage waste.

Extension Activities

1. Invite a waste management engineer to the class to explain site selection for sludge spreading, or write to an area waste management company and ask about sludge treatment and spreading.

2. Have students research different composting toilets and design a composting toilet system for a home or camp. What are the benefits and drawbacks?

3. Investigate alternative wastewater treatment technologies.



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Microorganisms: Bacterial Recyclers

9.CO.1.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: How microorganisms recycle

Subjects: Biology, Environmental Science

Materials: Deep trays or pans, soil, glass slides, water, containers, gentian violet or methylene blue, erythrosine or eosine, microscopes, wax pencil, organic material, source for flame to fix slides, beaker

Teaching Time: One class period to set up, observations over a three week period

Vocabulary: Natural recycling, microorganisms, decomposition

Note: This lesson is particularly effective when students have a background in microorganisms and bacterial shapes. In this activity, students will identify the organisms responsible for the composting process.

Learning Objective

Students will:

- relate the importance of healthy microorganisms to composting.

Background

See the Resource section for information on composting.

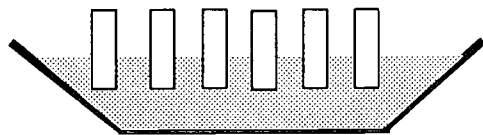


Figure 1: Slide Placement in Tray

Note: The tray should be about six inches deep to allow slides to be inserted into the soil.

Learning Procedure

Ask: What types of organisms are responsible for the composting process? List ideas on the board. Explain to students that **microorganisms** (an animal or plant of microscopic size, especially a bacterium or a fungus) are an important part of the **natural recycling cycle**.


1. Divide the students into small teams. Have each group fill one tray with dry soil and a second tray with soil plus 5 to 10 percent organic matter, well mixed. Adjust the moisture content to about 20 percent water by adding a volume of water corresponding to about 1/5 of the volume of soil.

Insert six slides vertically into each container as shown in Figure 1.

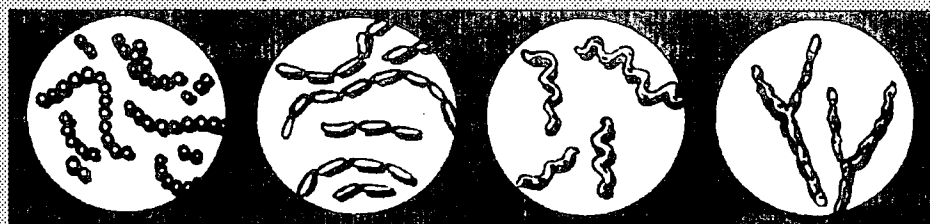
2. Six slides in each container will permit observation of each sample at the end of one, two, and three weeks. Each observation requires two slides, one stained dark and one stained light. Keep moisture content as constant as possible by adding water as needed. (You will do this during the next three weeks.)

3. After one week, have students examine two slides from each container according to the following procedure. Dig soil away from one side of the slide, then tilt the same slide toward the hole and lift it out. (Do not add moisture the day you will be removing the slides.)

4. The slide will now have a film of soil and microorganisms on one side. Have the students clean the other side with a cloth and label the slide with a wax pencil. Repeat for a second slide.



Minnesota has more composting programs than any other state. It has almost 400 of this country's 3,000 composting programs.
Source: *BioCycle* magazine, 1993



Cocci

Bacilli

Spirilla

Actinomycetes

Have students use illustrations in their biology books to help in identifying microorganisms.

5. The preparation on the slide is “fixed” by passing the slide over a flame – one or two passes should be sufficient. Stain one slide dark, using gentian violet or methylene blue. Stain the other slide light, using erythrosine or eosine.

6. Have each team examine their slides for bacteria with the low and high powers of a microscope. If present, *spirilla* will probably not be seen unless the field is darker. Have the students sketch what they see and compare them to the diagrams in Figure 2 to identify the morphological class of the bacteria. Are there differences in the number and types of microorganisms in each of the samples?

7. At the end of the second week, repeat the procedure with another pair of slides from each sample. Have the students determine if the number and types of bacteria in the samples have changed significantly. What might account for any observed changes?

8. At the end of the third week, repeat the procedure and make further comparisons. Have each team relate their observations and conclusions to composting.

Source: Reprinted with permission from *Oscar's Options*.

Extension Activity

Share with the class this information from *Garbage* magazine on how researchers are using microorganisms to digest toxic wastes.

White Rot Fungi

Scientists say white-rot fungi — wood degraders often found in fallen trees — may be an effective means of cleaning up certain kinds of toxic waste.

Biologists already knew that white-rot breaks down lignin, the complex molecule that binds wood together. At U.S. EPA's Office of Research and Development, researchers figured it could take on even more complex organic compounds. At a wood-treatment plant researchers formed 11 plots of soil taken from a waste-sludge pile and applied spores from three species of white-rot fungi collected from the undersides of old woden bridges. Through a series of biochemical reactions, concentrations of the toxicant pentachlorophenol (PCP) were reduced 85 to 90 percent, leaving behind much more benign byproducts.

Potential applications abound. PCP is often used as a wood preservative, and there are more than 55 wood-treatment plants nationwide on the U.S. EPA's Superfund list. In the days before strict environmental regulations, the plants merely dumped waste preservative into unlined lagoons and leaky storage tanks. These sites are already being cleaned up with bacteria that secrete chemical-eating enzymes. Bacterial methods are effective up to a point — the promise of white-rot, however, is that it can apparently break down tough compounds the bacteria can't.

“There's research left to do, but it could be a crucial clean-up technology,” says Steven Safferman, an environmental engineer at the U.S. EPA's Risk Reduction Engineering Laboratory in Cincinnati. “It has potential application at a lot of sites.”

— Ethan Seidman

Classroom Compost

9.CO.2.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: The benefits of composting

Subjects: Biology, Ecology, Environmental Science, Earth Science

Materials: See list of materials itemized below

Teaching Time: Two class periods (21 days apart), five to 10 minutes/day for days two through 20

Vocabulary: Decompose, organic, compost, humus, aerate

Learning Objectives

Students will:

- identify the components of an active compost pile
- explain the composting process
- identify current and potential markets and uses for finished compost products
- describe the benefits of composting as a waste management technique.

In this activity, students construct and monitor a classroom compost pile and discuss the benefits and uses of compost.

Materials

Striking It Rich With Compost information sheet (one per student), *Classroom Compost* data sheet (one per class), wire or screen compost container for outside compost or large glass container for indoor compost, organic yard and food waste (leaves, grass clippings, wood ash, sawdust, eggshells, fruit and vegetable food waste), lawn fertilizer that contains nitrogen, dirt or non-sterile potting soil, 1-2 dozen earthworms, thermometer, shovels or large kitchen spoons.

In South Carolina, yard wastes and grass clippings are banned from disposal in landfills. These materials should not be mixed with your household trash. They should be composted.



Background

For more on composting, see the Resource section.

Composting of materials is one of the oldest forms of recycling. When dead leaves fall to the ground in wooded areas, they are broken down and **decomposed** over time by a combination of physical (non-living) and biological (living) factors. Eventually, the elements and compounds which were once part of the living leaves are released into the air and soil where they can be used to form new plants or other organisms in the endless cycle of life. Given proper conditions, many of the organic wastes we throw away every day can also be decomposed and contribute to the natural recycling process.

Organic materials are carbon-based substances that are or were parts of living organisms. Composting is



In Guelph, Ontario, Canada, about 825 families are involved in an experiment to demonstrate that 60 percent of the municipal waste generated can be recycled and composted. Since the experiment began in 1989, this goal has been met. Now they are spending \$29 million on facilities to allow the practices to become a permanent way of life.

Source: 1994 *Environmental Almanac*

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a process whereby organic material is broken down and decomposed by microscopic bacteria, or fungi, and other decomposers, such as earthworms. When organic wastes, such as grass clippings, leaves, sewage sludge and food waste, are combined with decomposers and receive sufficient air and water, the decomposing organisms, especially bacteria, proliferate. The bacteria generate enough heat through metabolism that the temperature may reach 65.5°C. The finished product, called **compost**, is an important source of nutrients (such as carbon and nitrogen) for plants.

The large-scale use of composting as a waste management tool could significantly reduce the volume of solid waste communities send to landfills. At present, few South Carolina communities include large scale composting in their waste management programs. A major deterrent in developing large-scale use of composting is a lack of demand or market for the finished compost product.

As part of the South Carolina Solid Waste Policy and Management Act, yard clippings are banned from disposal in municipal landfills. This should spur interest in composting among communities.

Currently, composted yard waste and sewage sludge are used for soil enhancement and landfill cover and as a top dressing for grassy areas, vegetable gardens, and flower beds. Current major purchasers of compost are road and park departments, landscapers, golf courses, campgrounds, airports, and hay and corn farmers. Other potential purchasers include cemeteries, state and U.S. forests, homeowners, citrus growers, horse farms, topsoil and bark companies, retail farm and garden suppliers, phosphate miners, building contractors, and the fertilizer industry.

In addition to encouraging the development of additional large-scale composting facilities, homeowners are encouraged to use yard and food waste to make their own compost for use as fertilizer and/or mulch.

Learning Procedure

Note: *A few days before the compost preconstruction activity is scheduled, ask students to bring in samples of yard and food waste from home. Instruct students not to bring in meat scraps, fats, or oils. Food waste could also be obtained from student lunches. Also, it may be beneficial to find an outside location for storing your compost pile. There are many ways to build a compost pile, this lesson gives you several options. If you have a suitable site outdoors, you may dig a hole to use instead of building the pile in a container.*

Day 1

1. Introduce and define the term “compost.” Ask students to identify the “ingredients” they think are essential to a good compost pile and ask students to explain why these ingredients are necessary.
2. Distribute the *Striking It Rich With Compost* information sheet and review the nine components of an active compost pile. Next, explain the composting process and ask students what they think finished compost looks like. Explain that, when properly prepared, finished compost looks and smells like dark, nutrient-rich soil, or **humus**.
3. As a class, design and build a mini-compost pile in the classroom or outside in the schoolyard. A suggested procedure includes the following steps:
 - a. chop the food and yard waste into small pieces
 - b. alternate layers of soil (one inch), organic waste (two inches), a sprinkle of fertilizer, and a sprinkle of water
 - c. place a top layer of one inch of soil on the completed pile
 - d. add additional water as needed to make the pile moist but not soggy (it should feel like a damp sponge)
 - e. add earthworms to the top layer of soil
 - f. place a thermometer into the middle of the pile
 - g. **DO NOT SEAL THE COMPOST PILE – AIR CIRCULATION IS CRITICAL.**

4. Place the completed compost pile in an easily accessible area in the classroom or schoolyard and post the *Classroom Compost* data sheet nearby. Have one student record the initial temperature, odor and texture of the compost and list the organic waste materials added to the compost pile in the appropriate boxes next to START on the data sheet.

Days 2-20

5. Keep the compost pile away from extreme temperatures and direct sunlight. Assign a different student to examine the compost pile and use the data sheet to record data regarding the temperature, odor, texture, and changes observed in the compost pile each day. Once each week (Days 6, 11, and 16) use a trowel or large kitchen spoon to gently turn and aerate the compost. On these days, have students make and record their observations BEFORE the compost is turned and aerated. Remind students to record the temperature of the compost pile from the same location and depth and at the same time each day. Check the moisture level of the compost pile every few days and add water as needed to keep it moist.

Day 21

6. Record the final temperature, odor, and texture of the finished compost product and allow each student to feel, smell, and look at a sample of the finished compost. Have students help you construct a graph of the temperature of the compost pile over time and reproduce the completed *Classroom Compost* data sheet on the board or overhead.

7. Ask students what they think happens to organic food and yard wastes when they are buried in landfills. Explain that most landfills are not exposed to air, a critical component of the natural composting process. Without adequate aeration, most decomposing organisms cannot function properly. As a result, *organic* wastes buried in landfills can take decades to decompose. Inorganic compounds in a landfill never decompose.

In addition, without ventilation, methane gas, a natural product of the decomposition process is trapped in landfills. As methane gas builds up in landfills, it expands and has been known to 'float' or lift entire landfill cells. Now, all new landfills constructed must

include systems for collection and release of methane gas. Review the benefits of composting in reducing the volume of waste sent to landfills and recycling the elements and components necessary to sustain life. Tell students that according to U.S. EPA figures currently, 6.7 percent of the solid waste generated is food waste and 17.9 percent is yard waste.

Questions for the Class

1. List the nine components necessary for an active compost pile.
2. Write a paragraph explaining the composting process.
3. Identify at least two current and two potential markets/uses for finished compost products.
4. Explain the benefits of large-scale and home composting.
5. Why was it important to record the temperature of the compost pile from the same location and depth and at the same time each day?
6. How did the temperature of the compost pile change over time?
7. Why did the temperature of the compost pile change?
8. Were any odors produced during the composting process? Why does compost have an odor?
9. How did the texture of the compost change?
10. What happened to the original organic wastes added to the compost pile? Which materials were broken down and decomposed the fastest? Slowest? Why?
11. What could you do with the finished compost product? (*Explain that finished compost is a natural fertilizer and tell students that in natural settings, especially wooded areas, dead leaves, branches, and other organisms are naturally composted to produce humus, a nutrient-rich soil.*) Review the current and potential purchasers and uses

of composted sewage sludge and plant and yard waste compost in South Carolina. (*You might want to try the lesson: Spreading Sludge included in this curriculum.*)

Extension Activities

1. Have small groups of students design and monitor different kinds of compost piles (one low in nitrogen, one without moisture, one without aeration, one with sterile potting soil, one with a single organic waste ingredient such as banana peels, one without earthworms, etc.) Compare the rates and effectiveness of decomposition between piles.
2. Prepare one compost pile containing large pieces of organic waste and another containing small pieces of the same types of organic waste. Have students investigate the effect of material size on the rate and effectiveness of decomposition.
3. Collect samples of natural humus from a wooded area. Have students observe and compare the texture, odor, and color of natural humus and prepared compost and examine the humus for evidence of decomposers (fungi, earthworms, insects, etc.)
4. If your community has a municipal composting center, take a field trip to observe its operation.
5. Have students design and maintain a school or home compost pile using food and/or yard waste.
6. Have students prepare a Composting Fact Sheet and distribute it to classmates and family members.
7. Perform soil tests on natural humus, commercially obtained humus, and compost to determine how they compare. Grow seedlings in each, under identical conditions, to see if there are any differences. If differences occur, to what could you attribute the differences?

QUESTIONS ABOUT COMPOSTING

Will everything in the waste stream compost?

No. About 70 percent of the typical waste stream is compostable. This includes yard and food waste, paper, and wood.

What is the best method of composting?

There are several methods of composting. Choose the method based upon the materials you want to compost and the time you have to devote to composting.

Is composting considered recycling?

Yes, the United States Environmental Protection Agency includes composting in its definition of recycling.

What's the advantage in having a community composting facility?

Composting can reduce the dependence on landfilling and/or incineration.

How does compost benefit the soil?

A high quality compost properly applied to the soil improves soil structure and aeration as well as increasing its water-holding capacity. Compost improves the permeability of clay soils, and the water retention of sandy soils.

Is compost considered a fertilizer?

No. While compost can contain varying amounts of nitrogen, phosphorus, and potassium, it is considered a soil amendment, not a fertilizer.

What are typical uses for compost?

High quality compost can be used in horticulture, landscaping, and golf courses.

STRIKING IT RICH WITH COMPOST

KEY COMPONENT

FUNCTION

1. Soil

Contains microorganisms (bacteria) that help decompose organic materials.

2. Organic wastes (leaves, fruit and vegetable scraps, egg shells, and grass clippings) containing both carbon and nitrogen

Alternating layers of high-carbon and high-nitrogen wastes creates good environmental conditions for decomposition to occur.

Meat scraps, fats, and oils inhibit decomposition and their strong odors can attract dogs, rats, raccoons and other animals. They should not be used in compost piles.

3. Fertilizer containing nitrogen (or manure) or green grass clippings containing nitrogen

Many of the organisms responsible for decomposition need extra nitrogen for rapid and thorough decomposition.

4. Earthworms (optional)

Eat the waste and help break it down; Make droppings that enrich the soil; Tunnel through and aerate the waste thus aiding decomposition; Eventually die and become part of the compost.

5. Water

Essential component of the decomposition process; Too much water can make the compost pile soggy and slow decomposition by reducing needed oxygen.

6. Air

Fungi, bacteria, small insects, and other decomposing organisms require adequate amounts of oxygen to survive and function.

7. Time

Decomposition takes time; aerating the compost pile every few days can speed up decomposition.

8. Heat

Heat is a byproduct of the chemical reactions occurring during decomposition. A properly functioning compost pile can reach a temperature of 65°C. These high temperatures help sanitize compost by killing weed seeds, pathogens, and harmful insect larvae.

9. Mass

To generate enough heat for optimal decomposition, a compost pile should contain at least one cubic meter of organic material.

DATA SHEET

CLASSROOM COMPOST

Age of Compost Pile	Temp. (°C)	Odor of Compost	Texture of Compost	Changes in Organic Waste Materials (size, color, etc.)
START (DAY 1)				
DAY 2				
DAY 3				
DAY 4				
DAY 5				
DAY 6 (Aerate)				
DAY 7				
DAY 8				
DAY 9				
DAY 10				
DAY 11 (Aerate)				
DAY 12				
DAY 13				
DAY 14				
DAY 15				
DAY 16 (Aerate)				
DAY 17				
DAY 18				
DAY 19				
DAY 20				
DAY 21 (Finished compost)				

Household Hazards

9.HW.1.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Household hazardous substances

Subjects: Environmental Science, Home Economics

Materials: Sample of several hazardous products, community population estimates, *Product Labels* transparency, *Data Collection* form, *Know Your Home* sheet, *Safe Alternatives* sheet

Teaching Time: Two class periods, homework assignment

Vocabulary: Hazardous substance, hazardous waste, toxic, reactive, ignitable, corrosive, concentration

Learning Objectives

Students will:

- distinguish between a hazardous substance and a hazardous waste
- inventory and classify potentially hazardous household products
- use sampling methods to estimate the amounts of potential hazardous substances in households in their community.

Background

Around the house, it seems we can find hazardous products everywhere. To accomplish tasks efficiently and effectively with minimum effort, our society uses many products that contain hazardous substances. When we spray the bushes and clean the house, hazardous substances are being used.

Hazardous substances are chemicals that, if used improperly, can be dangerous to human health and/or the environment. When we have hazardous substances that are no longer useful or other substances that are contaminated with a hazardous substance, then what we throw away is hazardous

THE AVERAGE AMERICAN STORES THREE TO 10 GALLONS OF HOUSEHOLD HAZARDOUS PRODUCTS AT ANY GIVEN TIME. EXAMPLES OF HOUSEHOLD PRODUCTS THAT CONTAIN TOXIC OR POLLUTING CHEMICALS INCLUDE PAINTS, SEPTIC TANK CLEANERS, FINGERNAIL POLISH, DRAIN CLEANERS, DISINFECTANTS, POOL CHEMICALS, PESTICIDES, HOBBY SUPPLIES, CAR BATTERIES, AND LAUNDRY BLEACH.



waste. A household hazardous substance becomes household hazardous waste when we no longer have a use for it. **Hazardous wastes** are solids, liquids, or gases that can be harmful to human beings and/or the environment if not disposed of properly.

The United States Environmental Protection Agency (U.S. EPA) categorizes hazardous substances and wastes into four groups: **toxic** (poisonous), **reactive** (can explode or react violently if exposed to air or water), **ignitable** (able to catch fire), and **corrosive** (gradually dissolves other materials or containers).

You can assume a household product is hazardous if the label uses signal words that evaluate the product's potential. These signal words include danger, poison, warning, and caution. Other words such as pesticide, caustic, acid, flammable, or keep away from heat or open flames can also indicate that the product is potentially hazardous.

DOWN TO EARTH



The Federal Hazardous Substances Act regulated by the Consumer Safety Commission finds cleaning products to be some of the most dangerous substances in the home.

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HAZARDOUS WASTE CLASSIFICATIONS

Toxicity - Toxicity is measured by the potential for a waste to release substances in sufficient quantities to pose a substantial hazard to human health, domestic livestock and/or wildlife through ingestion, inhalation, or absorption. The U.S. EPA has identified maximum concentrations of heavy metals, pesticides, and herbicides over which significant risk to human health may occur. These concentration limits are set at a level 10 times the U.S. EPA/Primary Drinking Water Standard.

Reactivity - These are wastes that are normally unstable, may spontaneously and vigorously react with air or water, be unstable in the presence of shock or heat, generate toxic gases when mixed with water, and/or explode. Examples include obsolete munitions, cyanide- and sulfide-bearing wastes, and wastes from the explosives and chemical industries.

Ignitability - Ignitable wastes are liquids with a flash point less than 140°F for flammable gases, strong oxidizers, or substances that burn vigorously under spontaneous circumstances. Besides potential hazards from fire, heat, and toxic smoke, they can spread harmful particles over a large area. Examples include solvents such as toluene, xylene, and benzene; oils; plasticizers; and paint and varnish removers.

Corrosivity - Corrosive wastes are substances that can, upon contact, cause destruction of living tissues and materials by chemical action. They are generally water-based wastes with a pH less than or equal to 2 (acids) or greater than or equal to 12.5 (bases). Because they may corrode standard materials, such as steel, corrosive wastes require special containers. Examples: alkaline cleaners and battery wastes.

THE AVERAGE HOME CONTAINS 45 PRODUCTS THAT ARE POTENTIALLY HAZARDOUS IF STORED OR DISPOSED IMPROPERLY.

Although household hazardous wastes are exempt from the federal laws governing hazardous waste disposal, they are nevertheless a threat to the environment. It may seem acceptable for individual households to throw away small quantities of hazardous substances, but the cumulative impact of this habit can create serious environmental problems. Ground disposal (burying) of hazardous wastes can damage plants and contaminate water resources. Improper disposal in wastewater systems (pouring down drains) can damage pipes and eventually damage sewage treatment equipment or home septic tank systems since both of these processes are dependent on the actions of microbes for the breakdown of wastes.

People exposed to hazardous substances vary in their reactions. The individual characteristics of a hazardous material, the amount, and its concentration determine how a person reacts. Also, a person's age, genetic factor, lifestyle practices (smoking, alcohol consumption, obesity, and previous medical history), gender, and individual sensitivity affects his or her susceptibility. Many people are particularly sensitive to chemicals and experience allergic reactions to some toxic chemicals even in low amounts and concentrations.

Hazardous substances that are not reusable or recyclable should be taken to a household hazardous waste collection center or a mobile Amnesty Days collection center for proper disposal. However, these disposal options are not very common or readily available to many people in South Carolina. The best way to manage household hazardous waste is to reduce consumption and use of products containing potentially hazardous substances and to replace hazardous products with nonhazardous ones.

Learning Procedure

Day One

1. Hold the common product that contains hazardous ingredients where the class cannot see what you have and begin reading from the label. For example, if your product is a can of rubber cement or a common household cleaner, you would read the ingredients list and warnings from the label aloud. This is most effective when the product is a common one that most do not consider dangerous.

Ask: What do you think this is? Where do you think I found it? Should this be left out where anyone can reach it?

Define the terms “hazardous substance” and “hazardous waste” and review the major categories of hazardous wastes and substances. Ask students to name products in their homes that are examples from each hazardous substance category.

2. Project the *Product Labels* transparency and review the components of product labels. Label information can be vague and misleading. Trade secrecy laws allow manufacturers to forgo listing or defining ingredients on labels if it could lead to an economic loss for them.

Some labels describe the function of the chemical ingredient (grease cutter, corrosion inhibitor, polishing agent) rather than specifying what it is. Two common generic terms are petroleum distillates and organic solvent.

Petroleum distillates have varying degrees of toxicity, ranging from highly toxic benzene to nontoxic petroleum jelly. Specific organic solvents also have a wide range of toxicity and flammability.

Terms on labels, such as “active” and “inert,” are misleading. “Active” refers to those ingredients that actually do what the product is intended to do. “Inert” refers to any other substances in the product that make the active ingredient easy to apply and allow it to perform the job. Consumers often assume that “inert” means “nontoxic.” Inert ingredients may be equally or more hazardous than the active ingredients.

3. Distribute copies of the *Data Collection* form and *Know Your Home* sheet. Instruct students to collect data about hazardous substances in their homes. Ask them to examine the labels of products in their homes to identify hazardous substances listed on the *Know Your Home* sheet. Explain that for each product, the following information should be recorded on the *Data Collection* form:

- a. name of product
- b. product use
- c. name of potentially hazardous substance(s) in the product
- d. hazardous waste category of the substances (toxic, reactive, ignitable, corrosive)
- e. estimated volume of product in the container
- f. concentration of the substances (percent of each hazardous substance contained in product).

Remind students to check kitchens, bathrooms, laundry rooms, utility rooms, garages, closets, and hobby or garden areas for potentially hazardous products.

Day Two

4. Ask students to share and discuss their findings. Compile a list of potentially hazardous products found in the students’ homes.

5. To help students understand how to use sampling to make estimates, first ask them to estimate the number of households in the community using population information and assuming an average of 3.5 persons per household.

(Number of households equals
community population divided by 3.5)

Next, instruct each student to use the volume data from his/her *Data Collection* form to estimate the total amount of each hazardous substance present in the households of the community.

6. Have students share and compare their estimates for different hazardous substances. Ask students to estimate how much of each of these products and substances will eventually be thrown away, flushed down the sink or toilet into the public water system, or otherwise become hazardous waste. Ask students how reducing the use of hazardous substances would affect the quality of their lives.

7. Distribute copies of the *Safe Alternatives* sheet and discuss safe substitutes for common hazardous household substances. Have students discuss the pros and cons of substitutes. How do the costs compare?

Questions for the Class

1. Have students define the terms hazardous substance and hazardous waste.
2. Name two potentially hazardous products that can be replaced conveniently by safer substitutes.
3. The U.S. EPA categorizes hazardous substances into four categories. Name them.
4. What are some of the signal words found on the labels of hazardous household products?

A Note About Hazardous Substances At School

By examining and evaluating hazardous materials use, schools can develop pro-active management plans.

A school engaging in hazardous waste management, after careful planning, can avoid fines for violating state or federal regulations. A North Carolina community is paying one million dollars in cleanup costs because of school disposal errors. Of course, the most important reason to institute careful hazardous materials management is to protect yourself and your students.

The entire school community benefits from addressing hazardous materials use. Many people are accustomed to using hazardous materials in their everyday lives and have become desensitized to the potential health and environmental risks.

For more information about how to implement hazardous materials management in your school, write for a copy of *Hazardous Materials Management, A Manual for Schools*, from the Association of Vermont Recyclers, P.O. Box 1244, Montpelier, VT 05601 (802) 229-1833.

Just Do It

Organize, inventory, and label products containing hazardous substances at home. Inform family members and classmates of alternative safe substances for household cleaning, gardening, etc.

KNOW YOUR HOME

<u>Product Type</u>	<u>Hazardous Ingredients</u>	<u>Potential Hazards</u>
Air fresheners & deodorizers	Formaldehyde	toxic; carcinogen; irritates eyes, nose, throat, and skin; nervous, digestive, and respiratory system damage
Bleach	Sodium Hypochlorite	corrosive; irritates and burns skin and eyes; nervous, respiratory, and digestive system damage
Disinfectants	Sodium Hypochlorite	corrosive; irritates and burns skin and eyes; nervous, respiratory, and digestive system damage
	Phenols	ignitable; very toxic; respiratory and circulatory system damage
	Ammonia	toxic; vapor irritates skin, eyes, and respiratory tract
Drain Cleaner	Sodium or Potassium Hydroxide (lye)	corrosive; burns skin, eyes; toxic; nervous and digestive system damage
	Hydrochloric Acid	corrosive; toxic; digestive and urinary system damage
	Trichloroethane	toxic; irritates nose, eyes; nervous, digestive, and urinary system damage
Flea Powder	Carbaryl	very toxic; irritates skin; nervous, respiratory, and circulation system damage
	Dichlorophene	toxic; irritates skin; nervous, digestive system damage
	Chlordane and other Chlorinated Hydrocarbons	toxic; irritates eyes and skin; respiratory, digestive, and urinary system damage
Floor Cleaner/Wax	Diethylene Glycol	toxic; nervous, urinary, and digestive system damage
	Petroleum Solvents	highly ignitable; carcinogen; irritates skin, eyes, nose, throat, and lungs
Floor Cleaner/Wax	Ammonia	toxic; vapor irritates skin, eyes, and respiratory tract
Furniture Polish	Petroleum Distillates or Mineral Spirits	highly ignitable; toxic; carcinogen; irritates skin, eyes, nose, throat, and lungs

KNOW YOUR HOME (CONT'D.)

<u>Product Type</u>	<u>Hazardous Ingredients</u>	<u>Potential Hazards</u>
Oven Cleaner	Sodium or Potassium Hydroxide (lye)	corrosive; burns skin, eyes; toxic; nervous and digestive system damage
Paint Thinner	Chlorinated Aliphatic Hydrocarbons	toxic; digestive and urinary system damage
	Esters	toxic; irritate eyes, nose, and throat; nervous system damage
	Alcohols	reactive; ignitable; irritate eyes, nose and throat
	Chlorinated Aromatic Hydrocarbons	ignitable; toxic; digestive and urinary system damage
	Ketones	ignitable; toxic; respiratory system damage
Paints	Aromatic Hydrocarbon Thinners	ignitable; toxic; carcinogen; irritates skin; digestive and urinary system damage
	Mineral Spirits	highly ignitable; toxic; irritates skin, eyes, nose, throat; respiratory system damage
Spot Removers	Perchlorethylene or Trichloroethane	toxic; carcinogen; digestive and urinary system damage
	Ammonium Hydroxide	corrosive; toxic; vapor irritates skin and eyes; respiratory system damage
	Sodium Hypochlorite	corrosive; irritates and burns skin and eyes; nervous, respiratory, and digestive system damage
Toilet Bowl Cleaners	Sodium Acid Sulfate or Oxalate or Hypochloric Acid	corrosive; toxic; burns skin; digestive and respiratory system damage
	Chlorinated Phenols	ignitable; very toxic; respiratory, circulatory system damage
Window Cleaners	Diethylene Glycol	toxic; nervous, urinary and digestive system damage
	Ammonia	toxic; vapor irritates skin, eyes, respiratory tract
Wood Stains & Varnish	Mineral Spirits, Gasoline	highly ignitable; toxic; carcinogen; irritates skin, eyes, nose, throat; respiratory system damage
	Methyl and Ethyl Alcohol	ignitable; toxic; nervous system damage
	Benzene	ignitable; toxic; carcinogen; skeletal, digestive system damage
	Lead	toxic; digestive, reproductive, urinary, muscular, nervous system damage

KNOW YOUR HOME (CONT'D.)

<u>Product Type</u>	<u>Hazardous Ingredients</u>	<u>Potential Hazards</u>
Antifreeze	Ethylene Glycol	very toxic; circulatory and urinary system damage
	Methanol	toxic; nervous and respiratory system damage
Car Wax/Polish	Petroleum Distillates	toxic; carcinogen; irritates skin, eyes, nose; respiratory system damage
Herbicides (weed killers)	Chlorinated Phenoxys (contaminated with dioxin)	toxic; carcinogen; irritates skin, eyes and throat
Pesticides	Carbamates	toxic; nervous system damage
	Chlorinated Hydrocarbons	toxic; carcinogen; nervous system damage
	Organophosphorus	toxic; nervous system damage

SAFE ALTERNATIVES

Product Type

Safe Alternative

air fresheners & deodorizers

Open a window or use an exhaust fan.
Sprinkle baking soda in odor-producing areas or set vinegar out in an open dish.
Use scented, natural potpourri.

bleach

Use a baking soda and water cleaning solution.

disinfectants

Wash items with soap and water or with borax or sodium carbonate (baking soda) in water.

drain cleaner

Cover drains with screens to prevent clogging.
To loosen clogs: Mix 1 cup baking soda, 1 cup salt, 1 cup white vinegar and pour down drain. Wait 15 minutes. Flush drain with boiling water. Use a rubber plunger or a plumber's snake.

flea powder

Bathe animals with pet shampoo containing insect-repellent herbs such as rosemary, rue, eucalyptus, and citronella.

floor cleaner/wax

To polish: Mix 1 part thick boiled starch with 1 part soap suds. Rub on floor and polish dry with a clean, soft cloth.
To clean: Rub with club soda, scrub well, let soak, wipe clean.

furniture polish

Use olive oil, 100% lemon oil, beeswax, or 2 tsp. lemon oil and 1 pint mineral oil in a spray bottle.

oven cleaner

Wipe charred spills with a non-metallic bristle brush.
Scrub baked-on grease and spills with a baking soda, salt and water solution.

paint thinner

Use latex paint and eliminate the need for paint thinner.

paints

Use water-based paint and non-aerosol paints.

spot removers

Use white vinegar or a solution of equal parts of ammonia and water.

toilet bowl cleaner

Use 3 tbs. ammonia, 1 tbs. white vinegar and 3/4 cup water in a clean spray bottle or use a solution of 2 tbs. vinegar in 1 quart water.

pesticides

Garden: Spray plants with a solution of 3 tbs. soap per gallon of water.
Spray with pyrethrum (a chrysanthemum-based natural pesticide).

Household insect spray: Grind 1 clove garlic and 1 onion. Add 1 tbs. cayenne pepper and 1 quart water. Mix well. Let steep 1 hour and add 1 tbs. liquid soap.

window cleaner

Use a vinegar and water cleaning solution in a re-fillable spray bottle.
Polish windows with old newspapers.

Note: Ammonia is listed here as an ingredient in a safer alternative to commercial toilet bowl cleaner even though it was also listed earlier on the hazardous substance inventory. This points to the decisions that must be made in using some potentially hazardous materials to gain effectiveness.

[illegible]

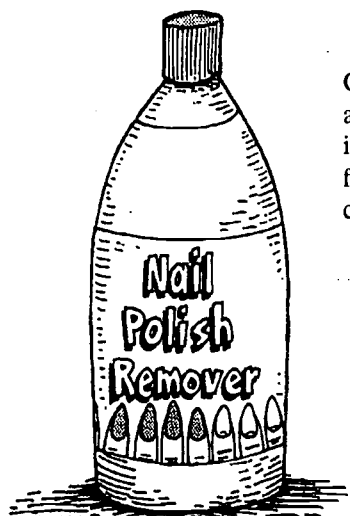
PRODUCT LABELS



Poison: May be fatal or cause permanent damage if swallowed. Causes severe burns to eyes and skin. Contains Sodium Hydroxide (caustic lye). May cause blindness. Avoid contact with skin, eyes, mouth and clothing. Keep out of reach of children.

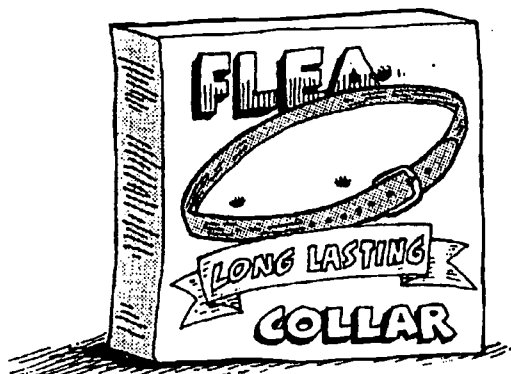


Danger: Extremely flammable. Harmful or fatal if swallowed. Combustible. Keep out of reach of children. Contains petroleum distillates. If swallowed do not induce vomiting. Call a physician immediately. Do not use or store near flame.



Caution: Flammable, keep from heat or flame. Keep away from small children. Harmful if taken internally. In case of accidental ingestion, give fluids liberally and consult with local poison control center.

**Watch out for these
... and other ...
Household Hazards**



Warning: Dust will form on collar during storage. Do not get dust in mouth or eyes. Harmful if swallowed. If in eyes will cause eye irritation. In case of contact, flush eyes with water. If irritation persists, get medical attention. Note to doctor/vet: dust released by this collar is a cholinesterase inhibitor. Atropine is antidotal. Active ingredient: o-isopropoxyphenyl methylcarbamate 9%.



Hazardous to humans and domestic animals: Warning: Keep out of reach of children. May be absorbed through skin. Do not breathe dust. Do not get in eyes, on skin, or on clothing. Wear rubber gloves when handling. Keep children and pets away from treated area.

Statement of practical treatment: If swallowed, give a large amount of water to drink, make person vomit and call a doctor. **Note to physicians:** This product contains a cholinesterase inhibitor. Atropine is antidotal. **Environmental hazards:** This product is toxic to fish and wildlife. Birds feeding in treated area may be killed. **Active ingredients:** phosphorodithioate 1%, inert ingredients 99%.

Trading Wastes

9.HW.4.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

Focus: Hazardous waste reduction and recycling, hazardous waste management, reusing

Subjects: Social Studies, Environmental Science, Health

Materials: Handouts included with this lesson

Teaching Time: One class period plus student research assignment

**HAZARDOUS WASTE FROM ONE INDUSTRY
MAY BE RAW MATERIAL FOR ANOTHER
INDUSTRY.**

**A WASTE EXCHANGE IS ONE WAY
FOR INDUSTRIES TO REDUCE BOTH THE
WASTE THEY THROW AWAY AND THE COST OF
HAZARDOUS WASTE DISPOSAL.**

Learning Objective

Students will:

- understand how reducing and recycling hazardous wastes can be both economically and environmentally sound
- know what a waste exchange is.

Background

In this lesson, students will discuss how businesses exchange waste materials. For example, lignin, which is a waste of paper pulp mills, is used by chemical manufacturers in the production of vanillin, the substance that gives artificial vanilla its taste. Chrome acid is needed for plating metals, and the chrome on your car or bicycle may have generated this hazardous chrome acid as a waste byproduct.

Waste can be reduced in a number of ways. One way is to prevent its production in the first place. North Carolina's Pollution Prevention Pays program is an example of a pioneer governmental effort to assist businesses with hazardous waste reduction. By offering technical help to companies trying to prevent wastes in the manufacturing process, businesses and industries learn that cutting

hazardous waste generation can actually save them money. Grants for waste prevention research and education are also funded.

In South Carolina, the Center for Waste Minimization of the South Carolina Department of Health and Environmental Control helps companies identify ways to reduce and eliminate waste. The Center for Waste Minimization assists companies in learning about alternatives to hazardous materials and how to get started reducing the sources of pollution and thereby reducing costly treatment and disposal. The center has provided technical assistance to more than 800 of the state's industries and has performed more than 150 on-site nonregulatory assessments. One of the center's most important jobs is sharing information about what waste reduction technologies work for certain industries and supplying information about how to contact recyclers, reclaimers, equipment vendors, and suppliers of nonhazardous alternative materials.

For more information, contact the Center for Waste Minimization, 2600 Bull Street, Columbia, S.C. 29201 (803) 734-4715.

DOWN TO EARTH



An Industrial Waste Exchange in New York reported that more than a million dollars worth of waste materials was exchanged in 1985. This is nearly six times the amount exchanged in 1984.

Source: *Away-With Waste* 9-12

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Waste exchanges are another way to reduce hazardous wastes. Most exchanges are nonprofit information clearinghouses. They list wastes available from various firms, make this information available, but do not take part in transactions. Many of these exchanges are government sponsored. Other exchanges are run for profit by private entrepreneurs who function as brokers. These firms receive a fee for each exchange transaction.

Amendments to federal laws now require companies to be strictly responsible for all the hazardous wastes they generate no matter how they are managed. Disposal in a landfill does not absolve a firm of this responsibility; thus, firms are now finding waste exchanges economically attractive alternatives.

Materials

- Overhead or handout: *Businesses Generating Hazardous Wastes*
- Handout: *Some Industrial and Commercial Hazardous Waste Categories*
- Handout: *Industrial Waste Exchanges*

Question for the Class

What is the preferred strategy for managing hazardous wastes? (*waste reduction*)

Learning Procedure

1. Put the number 356,947 on the board.

Ask: What does this number represent? (*The approximate tonnage of hazardous waste and hazardous wastewater generated in South Carolina in 1992 by industries.*)

2. Put the number 392,690 on the board. **Ask:** What does this number represent? (*The approximate tonnage of hazardous waste received by commercial off-site facilities in 1992, this includes waste imported to the state for treatment, storage or disposal, as reported by generators of 1,000 kg per month or greater.*)

3. Review the problems and concerns associated with hazardous waste disposal in landfills or its destruction in incinerators. (*Many people are concerned that landfills, even secure chemical landfills designed for hazardous wastes, may leak and pollute land and water. Many people fear that incineration of hazardous wastes pollutes the air.*)

4. **Ask:** What can industries do to reduce the amount of hazardous waste they generate? (*Change the manufacturing process; change the chemicals used in manufacturing processes; recycle spent or used material; find other companies that can use the wastes.*) List the responses on the board. Tell students that both federal and state waste management priorities emphasize hazardous waste reduction and recycling. Remind students that hazardous waste of some kind is a byproduct of many manufacturing processes: from the creation of medicines to the manufacturing of tennis shoes and televisions. Currently it is not possible for industry to just stop using hazardous materials. It is possible, however, for many industries to reduce and recycle some hazardous byproducts.

5. Distribute the handouts *Businesses Generating Hazardous Waste* and *Industrial Waste Exchanges* (or display as an overhead). **Ask:** Are there any wastes on the first list that might be used by other industries? (*Acids and bases are used by pulp and paper mills, steel mills, and many other industries. Solvents are used by a variety of manufacturers.*)

6. Explain how waste exchanges work and describe the two kinds of exchanges: informational exchanges and brokerages.

7. **Ask:** Why would a company use a waste exchange? (*Reduce storage space and save money; reduce disposal fees; reduce costs of supplies and substances used in manufacturing products; avoid violating the law in disposing of wastes; reduce transportation and/or storage costs involved in disposal.*)

Ask: Why might companies not use a waste exchange? (*Fear of liability for hazardous substances; takes too much time; costs too much.*)

8. **Ask:** What do all these reasons have in common? (*money*) What is the best way to help make a waste exchange work? How could governments encourage businesses to use waste exchanges? (*Tax breaks for firms that use waste exchanges; protect businesses that use waste exchanges from lawsuits; promote research on the recycling and reuse of hazardous wastes; develop grants to help small businesses. etc.*)

Ask students if they can think of any other institutions or organizations that could benefit from a waste exchange. (*Schools, colleges, government labs, military bases. etc.*) **Ask:** Does our school generate hazardous wastes? (*Yes, chemistry labs, industrial arts shops, arts and crafts classes, etc.*)

9. **Ask:** What is our school doing to reduce or recycle hazardous wastes? How can we find out? Form groups of three to five students and assign each group one of the following areas to investigate. Arrange to have someone available in each of these areas for students to question regarding hazardous waste generation and management.

- Chemistry labs
- Biology labs
- Industrial arts shop
- Arts and crafts classes
- Cafeteria, Food Service and Home Economics departments
- Printing and duplicating center
- Cleaning and maintenance shop

Have each group prepare a brief report to the class on what they find. This report should include information on the following:

- The kinds of hazardous substances used
- The kinds of hazardous wastes generated (Use the categories that are found on the handout *Some Industrial and Commercial Hazardous Waste Categories*.)
- Ways to recycle hazardous wastes
- The cost to dispose of the wastes now
- The regulations that apply to specific hazardous substances used or created
- How hard it would be to develop a way to recycle these wastes? (Could any of the hazardous wastes from one school area

be used by another? Could any of these wastes be avoided?)

10. When all the reports have been presented, discuss with students the problems and difficulties they encountered in finding out about the hazardous substances in their school.

Ask: How could we as individuals help promote environmentally and economically sound hazardous waste management strategies? (*Become informed about products that generate large amounts of hazardous substances in their manufacture; encourage companies to support research to find substitutes for these substances; write to your legislative representative about your opinion of supporting waste exchanges and hazardous waste regulations.*)

Extension Activities

1. Invite a speaker from the waste management industry, the South Carolina Department of Health and Environmental Control, and an environmental activist group to speak on the subject of waste exchanges and recycling to get a full spectrum view of the issues.

2. Have the class write for more information about waste exchanges from companies and industries that deal in nonhazardous and hazardous waste exchanges. These include:

- Southeast Waste Exchange
Urban Institute - UNCC
Charlotte, NC 28223
- Southern Waste Information Exchange
P.O. Box 960
Tallahassee, Florida 32302
- British Columbia Waste Exchange
2150 Maple Street
Vancouver B.C.
Canada V6J 3T3
- Alabama Waste Exchange
The University of Alabama
P.O. Box 870203
Tuscaloosa, AL 35487-0203

3. Have students review the list of the top 50 hazardous waste generators in South Carolina as reported in the document, *Hazardous Waste Activities Reported in South Carolina for 1992*, published by the South Carolina Department of Health and Environmental Control, 2600 Bull Street, Columbia, South Carolina 29201. Have students contact these companies to find out what they make, the hazardous waste generated as a result of this process, the state and federal hazardous waste reporting and regulations that the company must follow, and the methods the company uses to reduce or dispose of hazardous waste. Plot their locations on a South Carolina map.

SC's TOP 50 HAZARDOUS WASTE GENERATORS (In order of greatest amount generated)

Hardwicke Chemical	Albright & Wilson
South Eastern Chemical	Colonial Pipeline
Thermakem	AMP AKZO Co Carolina Circuits
Siemen Energy & Automation	Southeastern Coated Products
Safety-Kleen, Lexington Plant	Hodgson Chemicals Inc.
Laidlaw Environmental Services of SC Inc.	SC Galvanizing
Georgetown Steel	Torrington Company
Gaston Copper Recycling	Kemet Electronics
Nucor Steel	AVX
Owen Electric Steel	Norfolk Southern Railway Co. - Columbia
Philbro Tech Inc.	USN Charleston Navy Shipyard
Ethyl Corporation (Orangeburg Plant)	FN Manufacturing
Laidlaw Environmental Services (TOC)	Westvaco - Oleochemicals
DOE/WSRC Savannah River Site	King's Laboratory Inc.
CM Tucker Lumber	Mack Truck Inc.
3V Inc.	Oak-Mitsui
Hitachi Electronic Devices	Marathon Oil (A)
Schlumberger Industries	Marathon Oil (B)
Alumax of South Carolina	Westinghouse Electric Corp.
Koppers Industries Inc.	Reeves Brothers Inc.
Southern Coatings	Hickson Corporation
Macalloy Corp.	Sybron Chemicals
Safety-Kleen (Greer)	GE Gas Turbine Mfg.
Yuasa-Exide	
Fuji Photo Film	
WR Grace - Cryovac Division	
Haarmann & Reimer	

Source: DHEC's *Hazardous Waste Activities Reported in South Carolina for 1993*.

Businesses Generating Hazardous Wastes

Type of Business

Hazardous Wastes Generated

Auto Repair, and Maintenance

Lead-Acid Batteries
Heavy Metals
Solvents
Acids/Bases

Building Cleaning and Maintenance

Acids/Bases
Solvents

Cleaning Agents and Cosmetics

Acid/Bases
Heavy Metal/Inorganics
Solvents

Construction

Acids/Bases
Solvents
Preserving Agents

Electric and Computer Chip Manufacturers

Acids/Bases
Spent Plating Wastes

Farmers and Agricultural Service Shops

Pesticides
Solvents
Used Oils

Furniture/Wood Manufacturing/Refinishing

Solvents

Laundries and Dry Cleaners

Dry Cleaning Filtration Residues
Solvents

Motor Freight Terminals and Rail Transport

Acids/Bases
Lead-Acid Batteries
Heavy Metals/Inorganics
Solvents

Printing Industries

Acids/Bases
Heavy Metals/Inorganics
Ink Sludges
Spent Plating Wastes

Schools, Labs and Vocational Shops

Acids/Bases
Solvents
Heavy Metals/Inorganics

Wood Working (Boat builders, lumber mills, etc.)

Preserving Agents

Some Industrial & Commercial Hazardous Waste Categories

Waste Category	Hazard Characteristic(s)	Other Considerations
---------------------------	-------------------------------------	---------------------------------

Acids/Bases

Cyanide
Wastes

Filtration
Residues

Formaldehyde

Heavy Metals and Inorganics

Ink Sludges

Pesticides

Preserving
Agents

Solvents/
Degreasers

Spent Plating
Wastes

Industrial Waste Exchanges

Examples of waste most frequently advertised for exchange rather than disposal.

Acids: acetic, hydrochloric, sulfuric, chromic, sulfuric pickle liquor, nitric, nitric/hydrofluoric acid mix, and phosphoric

Alkalis: sodium hydroxide, lime, ammonium hydroxide, potassium, and potassium permanganate

Other inorganic chemicals: ammonium chloride, gypsum and ferric hydroxide, antiperspirant salts, diatomaceous earth, waste oxidizer, flame retardant, sodium tripolyphosphate, copper sulfate, cryolite, alumina/cryolite and alumina

Solvents: methyl ethyl ketone, isopropanol, stoddard solvent, cyclohexanone, acetone, 1,1,1-trichloroethane, pycmeme, various reclaimed solvents, and freon TF

Plastics and rubber: rubber, polyurethane, scrap tire chips, rubber sandings, polyvinyl chloride, inhibited styrene/polystyrene, latex polymer, polypropylene, and polyester film

Textiles and rubber: nonwoven fabric, nylon and polyester scrim, condenser fibers, rayon cloth, and rayon yarn

Wood and paper: wooden spools, newsprint, wooden pallets, and cardboard

Metals and metal sludges: copper filter cake, magnesium sludge, metal hydroxide sludge, barium sulfate, nickel catalyst, aluminum, zinc sludge, silver-copper-chrome mixture, zinc-iron, aluminum oxide coating powder, copper hydroxide sludge, copper and zinc sulfate, cadmium plating bath, copper solution, and molybdenum trioxide filter cake

Miscellaneous: calcium sulfate sludge, igneous rock fines, talc, brine, foundry sands, paint pigments, steel drums, laboratory chemicals, carbon, fiber drums, ion exchange resins, fiberglass, fly ash, carbon black, weld slag, coal ash, railroad ties, respirator filter cartridges, and grease

Some Industrial & Commercial Hazardous Waste Categories - Answer sheet

Waste Category	Hazard Characteristic(s)	Other Considerations
Acids/Bases	Corrosive, Reactive	Can sometimes react violently with water
Cyanide Wastes	Toxic	
Filtration Residues	Corrosive, Reactive, Toxic	
Formaldehyde	Toxic	Sensitive populations ¹
Heavy Metals and Inorganics	Toxic	Persistent, sensitive populations ²
Ink Sludges	Toxic	Persistent, sensitive populations ²
Pesticides	Toxic	Persistent ³
Preserving Agents	Toxic, Corrosive	
Solvents/Degreasers	Corrosive, Reactive, Ignitable, Toxic	Sensitive populations ¹
Spent Plating Wastes	Corrosive, Toxic	

¹ Some individuals are especially sensitive.
² Children are especially at risk to lead exposure.
³ Chlorinated pesticides can bioaccumulate.

REFUSE TRADING IS CATCHING ON

excerpts from an article that appeared in Waste Age magazine, Nov. 1989.

WASTE EXCHANGES NOW FACILITATE TRADES OF LARGE VOLUMES OF INDUSTRIAL NONHAZARDOUS WASTES.

Is there a market for waste produced in potato chip or corn chip processing? The supply is out there from just one company, 4,000 pounds a day – suitable for reuse as animal feed. How about a couple of loads of printed wallpaper, impregnated with vinyl acrylic resins – can it find a reuse as fuel? There are 40 tons per month available from one generator.

Generators of these wastes will be delighted to sell them to users at a price below that of virgin animal feed costs, in the case of the chips. Why? Such a sale will save the generating companies from paying landfill costs for these possibly reusable waste materials.

In fact, perhaps someone is already using the potato chip waste and the wallpaper, because these materials were listed recently in waste exchange catalogs. A waste exchange is similar to a dating service, except it puts together waste generators instead of couples. The exchange brings business and industrial companies to a meeting point, the catalog. This directory of available and wanted materials helps turn one company's waste material into another company's raw material.

Waste exchanges have been around for a little over a decade. Until about two years ago (when the last *Waste Age* article on exchanges appeared, in September, 1987), the listings were primarily hazardous wastes: acetic acid, hydrochloric acid, isopropyl acetate, and methanol. Potential uses include metal cleaning, neutralization, and wastewater treatment. And these continue to be listed frequently in waste exchange catalogs.

But as solid waste disposal costs have skyrocketed in the past two years, attention of waste exchange catalog

users has turned to finding uses for these nonhazardous wastes.

FIND USER, AVOID PAYING TIP FEE

Today, instead of landfilling, companies generating nonhazardous solid wastes are giving the waste exchanges a try. Listings from plastics to leather scraps to food wastes to railroad ties are found in waste exchange catalogs.

What's more, specific solid wastes—such as pine cones and apple peels—are being requested by the catalog's users. Basically, anything you want to sell or buy is listable in a waste exchange catalog.

"The market is really taking off in the area of solid waste ... partly because there is a lot more nonhazardous solid waste out there than hazardous waste," says Jeff Dauphin, executive director, Waste Systems Institute. Diane Shockey, contact at Industrial Materials Exchange Service, shares this belief: "There is more interest in nonhazardous waste use in exchanges than in previous years."

Some examples of successful and lucrative transfer of nonhazardous wastes:

- One company sold 364,370 pounds of textile waste, earning \$40,081.
- Another company gained \$11,574 from the transfer of 540,000 pounds of used batteries.

... And those figures don't include the savings each company pocketed by avoiding the cost of disposal. Waste exchange experts call this a "cost-benefit" or cost savings, says Mary McDaniel, director, Southeast Waste Exchange.

While listing companies net the cost-benefit, what's in it for the buyers? They net savings on raw material costs. Sometimes the savings are very, very big for, according

to McDaniel, "some companies will give away the waste, just to net the disposal costs savings." These firms are not so concerned with making a deal as avoiding disposal cost.

The waste exchanges themselves do not profit from the "married" parties. In fact, once a contact has been made by an interested party, the exchange notifies the listing company—that's all. The companies are left to negotiate prices, transportation, etc., without further exchange involvement.

Catalog listing fees range as high as \$75, and as low as free. Waste exchanges profit from listing fees, sale of catalogs, and paid advertisements. Most waste exchange revenue comes from state and local governments. Additionally, donations from environmental groups and private foundations support most exchanges.

Waste exchanges are sometimes directly affected by governmental action. Florida's establishment of a waste recycling/reduction goal (specifying disposal of 30 percent less waste by 1994) has helped provide a higher visibility for waste trading, says Eugene Jones, associate director of the Southern Waste Information Exchange. "It has a great effect on the number of solid waste transfers," says Jones.

"Governments are making monies available, generally on a state-by-state basis," says Dauphin. Regional exchanges "fear federal government funding of state operations ... resulting in inclusive states." Such a closed-border development would be self-defeating, according to Dauphin.

"There is a tremendous national emphasis on the management of waste, but no coordination between the federal government and states," he says. With increased governmental attention, the nation must avoid "undercutting regional operations."

THE ISSUE OF CONFIDENTIALITY

Most generators of hazardous waste prefer that their names not be tied to particular wastes. Competitors can easily learn secret manufacturing processes by the waste that companies advertise as "available."

New York law states that the identities of listing companies must be kept confidential, says Pickett Simpson, hazardous waste program manager at New York State Environmental Facilities Corporation. "It is important because of the competition in our area." Apparently, however, the importance of confidentiality varies by region. One of the largest exchanges, WSI, reports only 15 percent of the companies request anonymity. For WSI, "confidentiality used to be a big issue, before RCRA and Superfund, because industry never before publicly exposed the contents of the industrial waste stream," says Dauphin. "Since then, it (the number of requests for confidential listings) has tapered off significantly."

PLASTICS TRADING

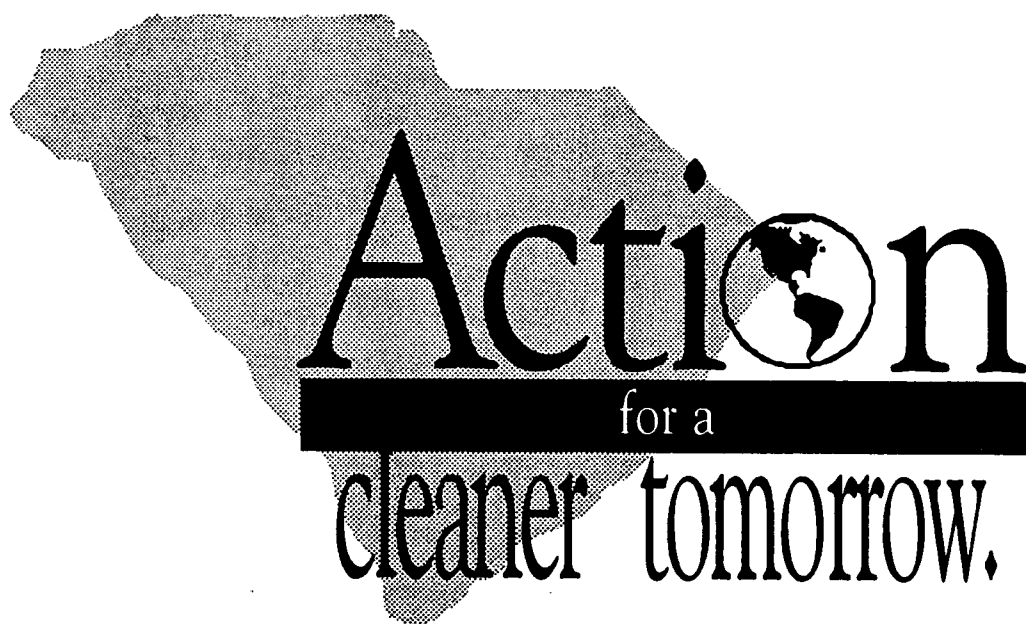
Actual exchanges of plastics recorded by the Southeast Waste Exchange [1988 figures] included:

- One party earned \$37,000 from the sale of 90,000 pounds of polyethylene
- Another company is earning \$54,000 annually on a transfer of 120,000 pounds of plastics, which saves the purchasing company \$90,000 in raw materials costs
- One industry earned \$4,000 on a transfer of 10,000 plastic containers
- Transfer of 84,000 pounds of plastic drums earned one listing company \$10,920.

Just Do It

Find out if any companies in your area take advantage of waste exchanges.





Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

From Cradle to Grave

9.HW.11.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

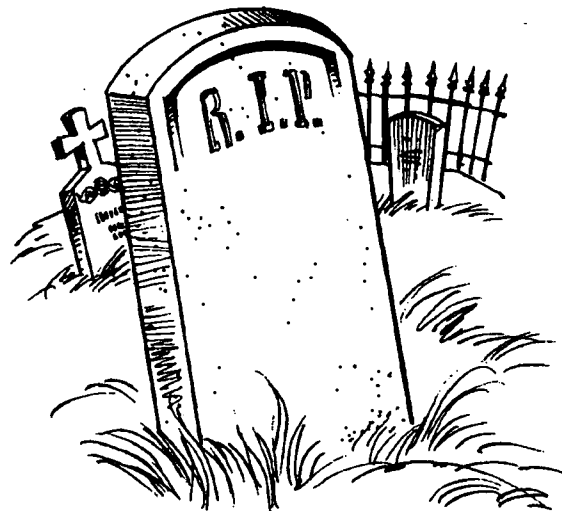
Focus: Hazardous waste management, decision making

Subjects: Biology, Environmental Science, Social Studies

Materials: See list of materials itemized

Teaching Time: One to two class periods plus outside project

Vocabulary: Cradle-to-grave, TSD, NIMBY, manifest



Learning Objective

Students will:

- learn that the heart of our national and state hazardous waste management program is “cradle-to-grave” tracking of hazardous waste
- understand how Treatment, Storage, and Disposal facilities (TSDs), help manage South Carolina’s hazardous waste.

Background

For more general information about hazardous waste, see the Resource section.

To make good decisions about the complex and controversial issue of managing hazardous waste, citizens need to know why hazardous waste is a problem, how it came to be a problem, and how hazardous waste is managed.

Both federal and state laws regulate the transport, storage, treatment, and disposal of hazardous substances. Companies that manufacture hazardous substances must register these chemicals with the U.S. Environmental Protection Agency (EPA), and

all shipments of hazardous materials must be accompanied by a **manifest** (shipping form) describing the nature of the hazard; precautionary instructions for handling, transport and disposal; and a statement of the quantity being shipped. The hazardous waste manifest is an eight-part form that tracks the waste shipment and provides confirmation that it has gone where it was suppose to go for disposal.

The owner of the substance must comply with the laws tracking the substance from its manufacture (the “cradle”) to its ultimate destruction or disposal (the “grave”).

The Resource Conservation and Recovery Act (RCRA) contains federal definitions and standards for hazardous waste disposal, including these “**cradle-to-grave**” provisions. Cradle to grave means liability does not end when waste leaves for disposal.

When waste leaves a company’s site, it becomes the shared responsibility of the waste disposal firm and

DOWN TO EARTH



There are 32 commercial hazardous waste landfills in the United States. One of these, Pinewood, is located in South Carolina.

Source: *Hazardous Waste Activities Reported in South Carolina 1995*

9-12
PAGE
113

the company that wants to dispose of the material, also known as the waste generator. The waste generator must obtain written acknowledgement from the certified disposal facility that the waste was received. The generator is still accountable for the waste after it reaches its final destination. If for any reason, a hazardous waste disposal facility should cause any environmental damage, everyone who sent waste there is responsible for a portion of the cleanup cost.

The ramifications of cradle-to-grave responsibility may discourage some hazardous waste generators from complying. The consequences of disposing of hazardous waste in municipal landfills are just as severe. A business that commits this kind of violation is held liable for a portion of the cleanup.

As the regulations have become stricter and more substances are tracked, a number of businesses have become specialists in treating, storing and/or disposing (TSD) of hazardous wastes. In South Carolina, there are many businesses that hold legal permits to treat hazardous waste, and any place that stores hazardous waste more than 90 days is required to have a hazardous waste storage permit. Not all TSD facilities handle all wastes.

Materials

- locations of South Carolina's off-site TSD facilities (included with this lesson)
- hazardous waste background from the Resource section
- a household hazardous product such as model airplane glue or fingernail polish.

Questions for the Class

1. What is meant by "cradle-to-grave" tracking of hazardous waste?
2. What is the role of treatment, storage, and disposal facilities (TSDs) in hazardous waste management?
3. How do you contribute to the production of hazardous waste?

Learning Procedure

1. Have students take out a blank sheet of paper. Tell students that a private company building a new plant in their town has decided to locate a hazardous waste treatment, storage, and disposal (TSD) facility to handle its waste.

Conduct a secret ballot of the students on how close to their homes they would be willing to accept a hazardous waste treatment, storage and disposal facility. Ballot choices can be:

- less than 1 mile
- between 1 and 3 miles
- between 3 and 7 miles
- between 7 and 15 miles
- more than 15 miles

Record their results on the board. Discuss why the students voted the way they did. **Ask:** If the choices had been arranged differently (downwind/upwind or upstream or downstream, for example), would their vote have changed? Why do you think a person might oppose or support the opening of a TSD in their town? How might they present their arguments? (*environmental concerns, lower property values, cause too much traffic; or it could provide high paying jobs, broaden the tax base of the county*)

Ask: What kind of information do you need to make an informed choice? Where can you get this information? (*libraries, the U.S. EPA, South Carolina Department of Health and Environmental Control, your local government, environmental organizations*)

2. **Ask:** Do you contribute to the production of hazardous waste? (*Yes, as consumers we demand the goods that are manufactured. Many manufacturing processes produce hazardous waste as a byproduct of manufacturing. The production of a car, for example, involves the generation of hundreds of pounds of hazardous waste. Some of this comes from the manufacture of chrome, which is used for hub caps, bumpers, hood ornaments, and other auto decorations such as paint. The manufacture of many everyday products such as tennis shoes, plastics, and many*

medicines, for example, generate hazardous waste. Manufacturing bicycles generates many of the same hazardous byproducts as those produced during the manufacture of cars. While many industries have been able to reduce the amount of hazardous waste in manufacturing, it would not be possible to eliminate them entirely.)

4. **Ask:** How much hazardous waste are we faced with disposing of every year in South Carolina? Write the figure 392,690 tons on the board. (*Explain that this is the amount of hazardous waste received by commercial, off-site treatment and disposal facilities in South Carolina in 1992. Also explain that 90 percent of all hazardous waste created by industry is handled on site by its generators.*)

5. **Ask:** In handling hazardous substances or disposing of hazardous wastes, what do we need to take into account? (*its effect on the environment and human health, cost of disposal, liability, management and disposal technologies, etc.*)

Ask: What have industries done in the past to dispose of hazardous waste? (*disposed of it in dumps and landfills; or, in some cases, discharged it into sewers, rivers, lakes, or the ocean*)

Ask: Do our laws allow this anymore? (*No. Treatment, shipment, and disposal of hazardous wastes are regulated.*)

6. Explain to students that both federal and state laws require that hazardous wastes be kept track of "from the cradle to the grave." This means companies must register and get a permit to manufacture, transport, or store a hazardous chemical (the "cradle"). These chemicals are then tracked as they are delivered to other manufacturers, wholesalers, retailers, etc. Each time the substance is moved or stored in a new location, documents describing the substance and its hazards must be carried along with it. A permit for final destruction or disposal (the "grave") is also required.

7. Discuss with the class the ways a company might deal with hazardous and unwanted byproducts. Have students think of all the ways a hazardous waste could be managed. List student responses on the board. Discuss the responses, including the following:

- **Treatment.** This involves making wastes less hazardous or even nonhazardous by some kind of treatment, either biological, chemical, or physical. Biological treatment includes any breakdown of substances by microorganisms, either natural or bioengineered (*for example, certain bacteria are known to consume oil*). Chemical treatment includes neutralizing acids with bases, oxidizing or reducing toxic metal compounds, etc. A common physical treatment is electrolysis whereby an electric current is passed through a solution, causing certain toxic ions to separate out of an otherwise nontoxic solution. Other physical treatments include magnetic separations, various filtration techniques, etc. **Ask:** What are the advantages of this strategy? (*avoids or reduces disposal and storage costs; prevents harmful substances from entering the environment; allows disposal of the resulting material as a nonhazardous, or less hazardous, waste*) What are the disadvantages? (*may be costly and require special training and equipment*)

- **Stabilization or Solidification.** This means creating a strong casing of glass or other impenetrable substance, which keeps the hazardous substance from moving into the environment. This technology is still mostly in the development stage. In South Carolina, some companies are mixing hazardous waste with a medium such as concrete and solidifying the waste so that it cannot leak from its container. **Ask:** What are the advantages of this method? (*does not require transporting of waste*) What are the disadvantages? (*requires monitoring over time and special expertise; does not really get rid of the waste; requires storage space*)

- **Storage.** This involves storing of dangerous waste, for a temporary period, at the site of generation (on site) or transporting it to other facilities for storage (off site). **Ask:** What are the advantages of this method? (*requires little handling, less expensive*) What are the disadvantages? (*only a temporary management technique, does not get rid of waste*)

- **Recycling or Reuse.** This involves either returning a spent material, after reprocessing, to the original process as a substitute for raw materials or reusing the spent material in a new process.

Ask: What are the advantages of this method? (*decreases hazardous waste disposal cost; reduces amount of waste needing disposal; manufacturers can obtain needed materials at a lower price.*) What are the disadvantages? (*potential liability issues, availability of needed materials*)

- **Disposal.** Disposal includes landfilling in a chemical secure hazardous waste landfill. These landfills are federally regulated and must have a liner system and detection for leaking.

- **Trading.** The byproducts or scrap materials of some manufacturing processes may or may not be hazardous, but they are the waste product of that particular process. However, these same byproducts and scraps may be a necessary ingredient or raw material for another manufacturing process. States such as New York and Washington have made attempts to identify and quantify these byproducts and make lists of these “inventories” available to industry. In South Carolina, the South Carolina Department of Health and Environmental Control’s Center for Waste Minimization offers assistance to companies looking to reduce or recycle wastes. South Carolina companies can also participate in waste exchanges. The Southeast Waste Exchange, headquartered in Charlotte, North Carolina, offers a waste exchange service that connects companies with materials.

8. Share with the class the list of the South Carolina Treatment, Storage, and Disposal facilities. Tell students that TSDs are an important component of South Carolina’s current hazardous waste management system. TSDs are companies in the business of treating, storing, and disposing of hazardous waste. To stay in business, waste storage and disposal companies must comply with all applicable state and federal regulations regarding hazardous waste. You may want to take a state map and pin point the locations of these facilities in your area. **Ask:** If we contribute to and benefit from the production of hazardous waste, shouldn’t we contribute to its management?

9. Explain the concept of NIMBY (Not In My Back Yard) as it relates to waste disposal. The NIMBY

reaction comes from people that protest having waste disposal facilities in their community. **Ask again:** If we contribute to and benefit from the production of hazardous waste, shouldn’t we contribute to its management?

10. If a town, city, or county has businesses that manufacture and/or use hazardous materials, discuss whether the citizens of that community should protest siting of facilities that manage and dispose of hazardous wastes. **Ask:** Does our city have any businesses that might generate hazardous wastes? (*Remind students that many businesses – from dry cleaners to photo processing shops to farms to auto shops to hospitals – generate hazardous waste.*)

11. Form groups of three or four students. Distribute the hazardous waste chapter from the Resource section to the groups to use as research and encourage the groups to do further research on their own. Have them find out where hazardous waste is generated in your community. What kind? How much? Where is it disposed? How does it get to the disposal site? Have each group prepare a brief presentation on the problems of managing hazardous wastes and their ideas for improving the situation. These ideas can involve new technology, social change, new laws, etc. Presentations may be written (one or two pages) or oral (no more than five to ten minutes). Have each group give its presentation to the class.

Pick an actual site in your city or county. Create a secret ballot that asks students to vote “yes” or “no” on siting a hazardous waste facility at this location. On the ballot, have the voter indicate how close he or she lives to this site using the choices listed previously. After the students have made their presentations, have them distribute the ballots to the class and ask the class members to vote. Stress that the ballots are secret.

Tabulate the results and determine if there is any direct correlation between nearness to the facility and a “no” vote. This is best done using percentages of the total votes for each distance range. Draw bar graphs displaying the results.

If no one wants a TSD facility nearby, discuss what should be done with our hazardous waste. (*reduce the amount generated by industries; become informed consumers concerning products that generate hazardous wastes; promote recycling of wastes, etc.*)

Extension Activities

1. Attend a public hearing on hazardous waste management issues that the South Carolina Department of Health and Environmental Control conducts around the state. Call 1-800-SO-USE-IT for information on the next hearing being held near your city or town.

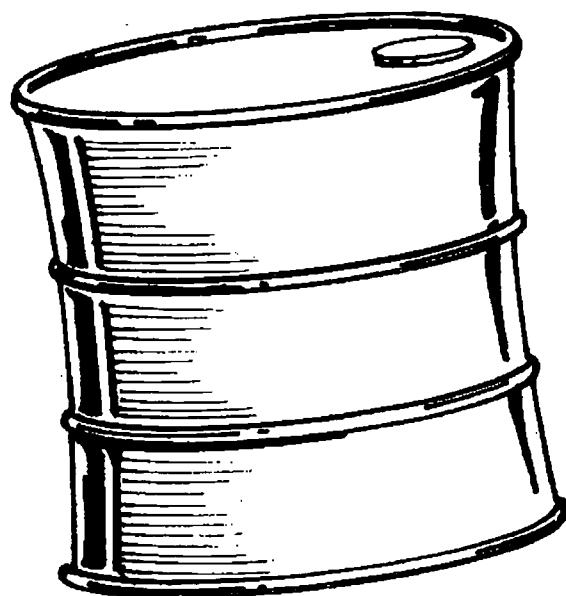
Have students research newspaper coverage of these public hearings. Do the papers cover these hearings? How much space is devoted to these hearings? Where are these articles placed throughout the newspaper (front page or near the back)? Why?

2. Do the activities entitled: *What's In Those Barrels?* and *Deciding What To Do* included in this curriculum.

3. Invite a representative from a TSD facility to speak to the class. Call your regional DHEC Office for information.

Just Do It

To learn more about hazardous wastes in South Carolina, contact the South Carolina Department of Health and Environmental Control, 1-800-SO-USE-IT, for a copy of the Hazardous Wastes Activity Report. This report is produced annually.



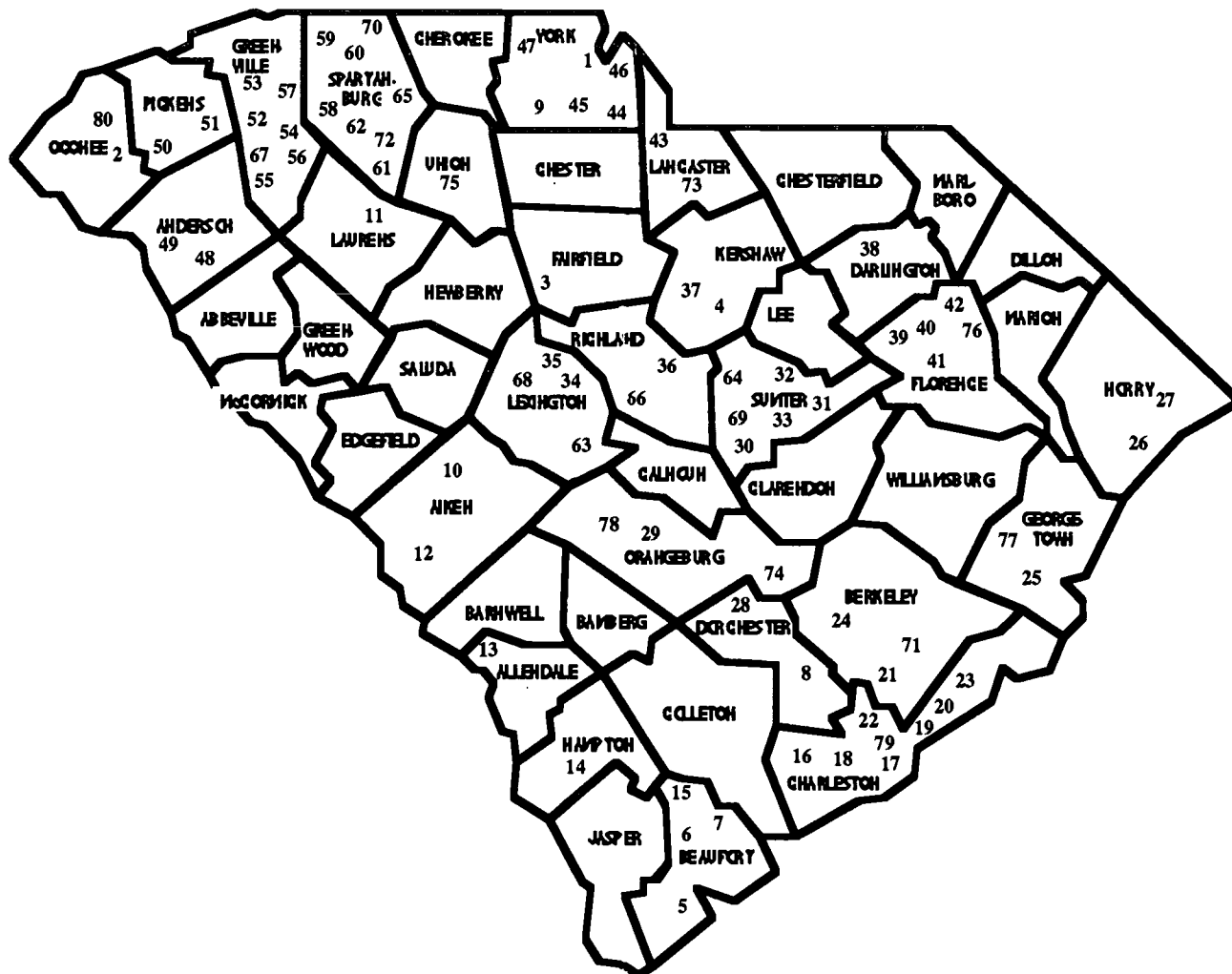
Nationally, more than 90 percent of all hazardous waste is handled on site by the generator.

In South Carolina, the majority of hazardous waste generated is handled by the generator, on site. These generators have permits that allow them to handle their own wastes. They are allowed to store hazardous wastes at their site for as many as 90 days.

Generators that handle their own hazardous wastes are regulated by state and federal laws and are monitored for compliance.

Have students research the disposal practices of companies in their area.

Locations of South Carolina's Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities



Key

- | | | | |
|-----------------------------------|-----------------------------------|-------------------------------------|-------------------------------------|
| 1. Duke Power - Clover | 20. Albright & Wilson, Inc. | 41. Safety-Kleen - Florence | 62. Siemens Energy & Automtn. |
| 2. Duke Power - Oconee | 21. USN Chas. Weapons Station | 42. Koppers Company, Inc. | 63. Gaston Copper Recycling |
| 3. SCE&G - Sumner | 22. USAFB Charleston | 43. So. Screen Engravings, Inc. | 64. USAFB Shaw |
| 4. Hardwicke Chemical | 23. US Naval Shipyard Chas. | 44. Landfill, Inc. | 65. Blackman-Uhler Chem. Div. |
| 5. USMC Recruit Depot | 24. E.I. DuPont - Cooper River | 45. Thermalkem, Inc. | 66. Ashland Chemical Co. - Cola. |
| 6. ABEX/NWL Aerospace | 25. Georgetown Steel Corp./GE | 46. Hoechst-Celanese - Rock Hill | 67. Ashland Chemical Co. - G'ville |
| 7. USMC Air Station | 26. USAF Myrtle Beach | 47. North Hand Protect. - Clover | 68. Safety-Kleen - Lexington |
| 8. Safety-Kleen - Summerville | 27. Wol. Brass Works/D. Walthe | 48. Owens Corning Fiberglass | 69. USAF Poinsett Range |
| 9. Leonard Chemical Co., Inc. | 28. Giant Cement Co. | 49. Eliskim Inc. | 70. Hudson International Conductors |
| 10. United Defense LP | 29. Cox Wood Preserving Co. | 50. BASF | 71. Miles, Inc. |
| 11. Torrington - Clinton | 30. Laidlaw Enviro. - Pinewood | 51. Hollingsworth Saco Lowell Co. | 72. Laidlaw Enviro. Ser. - TOC |
| 12. SRS | 31. SE Chemical & Solvents | 52. Carolina Plating Works, Inc. | 73. Thomas & Betts, Inc. |
| 13. Sandoz Chemicals Co. - Martin | 32. Southern Coatings Inc. | 53. T&S Brass & Bronze Works | 74. Holnam, Inc. |
| 14. Westinghouse Electric Corp. | 33. Philbro-Tech, Inc. | 54. Steel Heddle Mfg. Co. | 75. Torrington - Tyger River Plant |
| 15. Le Creuset of America, Inc. | 34. Owen Electric Steel Co. | 55. Roy Metal Finishing Co. | 76. DuPont - Florence |
| 16. Lockheed-Georgia | 35. Allied Corporation | 56. G.E. Gas Turbine | 77. VVV |
| 17. North Hand Protection - Chas. | 36. USA Ft. Jackson ATC | 57. Hoechst-Celanese - Greer | 78. Albemarle Corporation |
| 18. Moore Drums, Inc. | 37. E.I. DuPont - May Plant | 58. Safety-Kleen - Greer | 79. Macalloy Corporation |
| 19. Medical University of S.C. | 38. Intl. Minerals & Chemical Co. | 59. Milliken Chemical - Dewey Plant | 80. Schulmberger |
| | 39. ESAB Welding Products, Inc. | 60. Southern Wood Piedmont Co. | |
| | 40. General Electric Co. | 61. MEMC Elec. Materials, Inc. | |

A Little Can Mean A Lot

9.HW.12.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Hazardous waste generators, school hazardous wastes

Subjects: Science, Environmental Science

Materials: *Hidden Hazards* data sheet, *Potential Hazards Inventory* sheet

Teaching Time: Two class periods

Vocabulary: RCRA, hazardous waste, toxic, reactive, ignitable, corrosive, large quantity generator, small quantity generator, household hazardous waste, waste exchange



Learning Objectives

Students will:

- distinguish between small quantity and large quantity hazardous waste generators
- list examples of small quantity hazardous waste generators
- categorize potentially hazardous wastes found at their school
- identify and explain three strategies small quantity generators can use to reduce the amount of hazardous waste produced.

Hazardous wastes are solids, liquids, gases, or sludge materials that present a hazard to human health or safety or to the environment unless they are properly stored, transported, treated, or disposed.

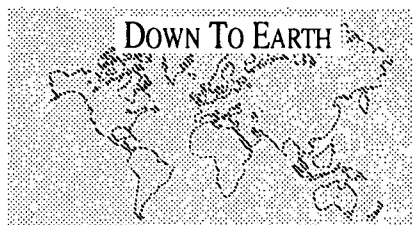
RCRA categorizes hazardous waste into four groups: **toxic** (poisonous), **reactive** (can explode or react violently if exposed to air or water), **ignitable** (able to catch fire or "flammable"), and **corrosive** (gradually dissolves other materials or containers).

Background

In 1976, the United States Congress enacted the Subtitle C Resource Conservation and Recovery Act (**RCRA**), designed to protect public health and the environment from improper management of hazardous waste.

RCRA controls hazardous waste by setting standards for hazardous waste disposal and tracking hazardous waste from generation to disposal.

When we think of hazardous wastes and materials, we often think of bubbling chemicals, thick fumes, and oozing slimy materials produced in laboratories. In reality, hazardous wastes are generated every day by industries, agriculture, the military, small businesses, public agencies, institutions, and homeowners. Originally RCRA was written to regulate hazardous waste produced by the **large quantity generators**: industries, agriculture, and the military. Large quantity generators generate more than 1,000 kilograms of hazardous waste per month.



At the Earth Summit in Rio De Janeiro in 1992, some 15,000 participants representing *nongovernmental* organizations from 165 nations held a parallel forum to the governments that met at the official conference.

Source: 1993 *Earth Journal*

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RCRA has since been amended to regulate the previously exempted **small quantity generators** including small businesses, public agencies, and institutions such as schools, hospitals, and maintenance crews. Small quantity generators are those who generate less than 1,000 kilograms of hazardous waste in a calendar month. Some small quantity generators are conditionally exempt.

The small amount of hazardous wastes found in homes, **household hazardous waste**, has remained exempt from federal regulations.

Small businesses that are likely to produce hazardous wastes include those that: repair and maintain motor vehicles, electroplate materials, operate printing and copying equipment, perform dry cleaning and laundering services, process photographs, operate laboratories, construct buildings and roads, spray lawns and/or homes for pest control, preserve wood, make or refinish furniture, paint and clean buildings, clean and maintain swimming pools, repair air conditioners, and make and glaze ceramic pottery.

The actual amount of hazardous waste generated by a single small business or school may seem insignificant, but the amount from all these sources adds up to a profound threat to the environment if not properly handled.

To identify and properly manage the hazardous waste produced by small quantity generators (SQGs), South Carolina requires reporting annually by companies generating between 100 kilograms and 1,000 kilograms per month. For 1992, 1,046 small quantity generators reported.

Although the majority of small quantity generators are small businesses, many schools also generate significant amounts of hazardous wastes. Often, these wastes are improperly disposed by unknowing teachers, custodians, and clerical staff who pour hazardous wastes down sink drains, dump them on the ground or in storm drains, bury them in containers that can leak over time, or put them in garbage cans or dumpsters for disposal in municipal landfills. Improperly managed hazardous wastes can

pollute our ground water, contaminate rivers and lakes, kill fish and other wildlife, pollute the air with toxic vapors, cause explosions or fires, and poison humans from direct contact or consumption of contaminated plants and animals.

Many hazardous waste generators – especially the large quantity generators – treat, store, or dispose of their wastes on site under federal and state regulations. The technology and equipment for this activity is expensive and usually too costly for small quantity generators. The most economical way for small quantity generators to manage their hazardous waste is to have it shipped to approved disposal facilities.

Like any other kind of waste, the less hazardous waste a generator produces, the easier it is to manage. Small quantity generators can reduce the amount of hazardous waste they produce by recycling waste materials, participating in **waste exchanges** with other small quantity generators, and using alternative nonhazardous substitutes for potentially hazardous products. Hazardous wastes that can be recycled for further use include lead in car batteries, and silver from used photographic fixer. In many cases, one generator's hazardous waste can be another industry's raw material.

In our area, small and large quantity generators can call the Southeast Waste Exchange in Charlotte, North Carolina and list their wastes in a publication that is circulated to other generators, recyclers, and waste brokers.

Learning Procedure

1. On the board write the names of several small businesses in your town – the local cleaners, the photo processing shop, furniture refinishers, swimming pool cleaners, pest control, etc – that would be small quantity generators. **Ask:** What do these businesses have in common? *(Let the class name what they think these businesses have in common. They may say that these businesses perform important services, or that they use chemicals. Explain to the class that these businesses are all examples of the types of small*

businesses that produce hazardous waste as a byproduct of their business.)

Define the term "hazardous waste" and explain the difference between a large quantity and small quantity hazardous waste generator. Provide examples of large and small quantity generators.

2. Briefly explain the Resource Conservation and Recovery Act (RCRA) and list and define the four major categories of hazardous waste. Ask students to provide examples of each type of hazardous waste.

3. As a class, brainstorm a list of all of the places in the school where potentially hazardous wastes might be found. Examples include custodial supply rooms, kitchen, chemistry laboratory, biology laboratory, journalism and/or photography rooms, drama department property room, office supply cabinet, photocopy/duplication area, art rooms, lawn/grounds maintenance store room, and vocational areas and classrooms.

Divide students into groups of three or four and assign each group to one area on the list.

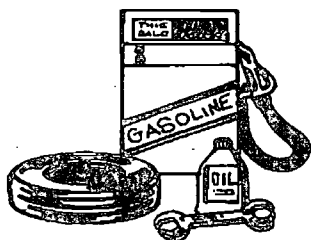
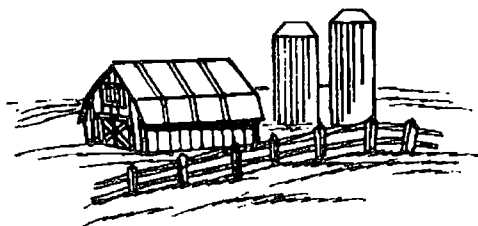
4. Distribute copies of the *Hidden Hazards* data sheet and review examples of potentially hazardous wastes commonly found at schools. Distribute a copy of the *Potential Hazards Inventory* sheet to each group and

instruct each group to inventory its assigned area and try to categorize the potentially hazardous wastes found. Tell students they can assume a product is potentially hazardous if the label contains words like pesticide, caustic, poison, acid, flammable, warning, caution, danger, harmful if inhaled or swallowed, keep away from heat or open flames, use in a well-ventilated area, and avoid direct contact with skin.

For each potentially hazardous product identified, ask students to record any warnings or disposal information included on the product labels. (*Note: You should contact teachers, office staff, and custodial staff in advance to arrange convenient times for student visits. Students should be supervised at all times during their inventories. Students should be instructed not to touch anything. Teachers should wear gloves and safety glasses and assist students in turning products to see labels. If your school does not keep hazardous materials properly stored in locked cabinets, this is an excellent time to see that these safety precautions are taken.*)

5. After all groups have completed their inventories, compile a complete list of potentially hazardous wastes found at the school. Explain to students that there is a difference between hazardous materials and hazardous wastes.

Small Quantity Generators of Hazardous Waste



The actual amount of hazardous waste generated by a single small business or school may seem insignificant, but the amount from all these sources adds up to a profound threat to the environment if not properly handled.



Hazardous wastes are hazardous materials that are no longer useful and are being disposed. Many of the hazardous materials found will be used entirely and will not result in hazardous waste. Conduct a whole class discussion addressing the following questions:

- What area of the school contains the greatest number of different potentially hazardous wastes?
- What is the most common category of hazardous material found at school? What is the least common category of hazardous material found at school?
- What kinds of warnings were found on potentially hazardous product labels?
- What kind of disposal information was found on potentially hazardous product labels?

6. Tell students that more than 356,947 tons of hazardous waste and hazardous wastewater are generated in South Carolina every year. Explain that the best strategy for dealing with the hazardous waste management problem in South Carolina is reducing the amount of hazardous waste requiring treatment and/or disposal. Discuss the three techniques small quantity generators can use to economically manage and reduce their hazardous waste: recycling, participating in a waste exchange, and using nonhazardous substitutes.

7. Collect completed student inventories and check for correctness.

Questions for the Class

1. Ask students to explain the difference between small quantity and large quantity hazardous waste generators and list three examples of small quantity hazardous waste generators.

2. Have students name and briefly explain three strategies small quantity generators can use to reduce the amount of hazardous waste produced.

Extension Activities

1. Have students investigate CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act 1980), also known as *Superfund*. This federal legislation, administered by the U.S. Environmental Protection Agency, regulates cleanup and liability for hazardous waste sites. It also established reporting requirements for releases of designated substances into the environment.

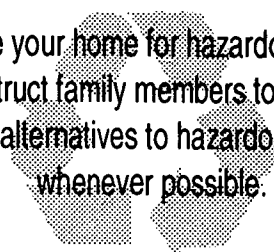
Have students research the Emergency Planning and Community Right-To-Know Act, commonly known as Title III of the Superfund Amendments and Reauthorization Act (SARA Title III).

2. Have students prepare a School Site Hazardous Waste Fact sheet containing a list of typical hazardous products found at school and proper handling, storage, and disposal information. Distribute the fact sheet to teachers, custodians, and clerical staff.

3. Have students research more information about waste exchanges and the materials that are exchanged. The addresses of several waste exchanges are listed at the end of this activity. Students may also contact local businesses and industries to find out if any of these companies are exchanging or recycling any of their wastes (hazardous and nonhazardous.)

Just Do It

Investigate your home for hazardous products.
Instruct family members to try to
use safe alternatives to hazardous products
whenever possible.



HIDDEN HAZARDS

School Site

Custodial Supply Room

Potentially Hazardous Wastes

Floor cleaner/wax
 Drain cleaner
 Bleach
 Disinfectant
 Ammonia
 Deodorizing cleaners
 Toilet bowl cleaner
 Air freshener
 Carpet and rug shampoo
 Window cleaner
 Furniture polish

Kitchen

Drain cleaner
 Oven cleaner

Chemistry Laboratory

Acetone
 Acids
 Alcohols
 Bases
 Benzene
 Chromium
 Heavy metals
 Mercury thermometers

Biology Laboratory

Formalin
 Ether
 Alcohols
 Mercury thermometers
 Staining solutions

Art Room

Glue/epoxy
 Ceramic glazes
 Paints
 Paint thinner
 Inks
 Paint solvents
 Shellac/fixative

Journalism/Photography Room

Inks
 Photographic chemicals
 Glues

Drama Department Property Room

Paints
 Paint thinner
 Paint solvents
 Wood stains/varnish
 Cosmetics/make-up

Office Supply Cabinet

Furniture polish
 Glues
 Ditto correction fluid
 Typewriter correction fluid

Photocopy/Duplication Area

Photocopy machine inks/toners
 Photocopy machine cleaners
 Ditto machine fluid
 Ditto machine cleaner

Lawn/Grounds Maintenance Storeroom

Gasoline
 Insecticides
 Herbicides

Vocational Areas and Classrooms

Automotive batteries
 Gasoline
 Antifreeze
 Wood stains/varnish

POTENTIALLY HAZARDOUS MATERIALS

SCHOOL LOCATION _____

Potentially Hazardous Product	Category				Warnings	Disposal Information
	T	R	I	C		

THERE ARE MORE THAN 20 WASTE EXCHANGE ORGANIZATIONS THROUGHOUT NORTH AMERICA.

Alberta Waste Materials Exchange

350, 6815 8th St. NE

Calgary, Alberta

CANADA P2E 7H7

British Columbia Waste Exchange

1525 West 8th Avenue, Suite 102

Vancouver, BC V6J 1T5

California Waste Exchange

P.O. Box 806

Sacramento, CA 94212-0806

Canadian Waste Materials Exchange

2395 Speakman Drive

Mississauga, Ontario

CANADA L5K 1B3

Industrial Materials Exchange Service

P.O. Box 19276

Springfield, IL 62794-9276

Louisiana/ Gulf Coast Waste Exchange

1419 CEBA

Baton Rouge, LA 70803

Manitoba Waste Exchange

1812-330 Portage Avenue

Winnipeg, Manitoba

CANADA R3C-0C4

Northeast Industrial Waste Exchange

620 Erie Blvd. W., Suite 211

Syracuse, NY 13204-2442

RENEW

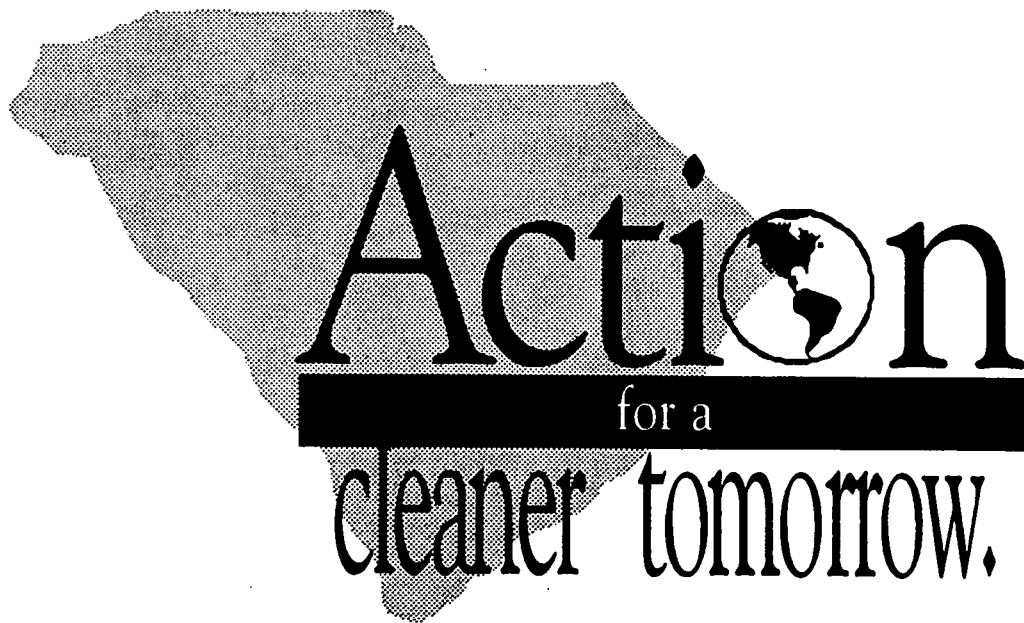
P.O. Box 13087

Austin, TX 78711-3087

Southeast Waste Exchange

UNCC Station

Charlotte, NC 28223



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For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

The Cost of Industrial Waste

9.HW.5.F

Preparation Time: Easy To-Do Moderate Extensive

Grade: 11 – 12

Focus: Industrial waste and disposal

Subject: Economics

Materials: See list of materials itemized below

Teaching Time: Two class periods

Vocabulary: Waste, resource, raw material

Learning Objectives

Students will:

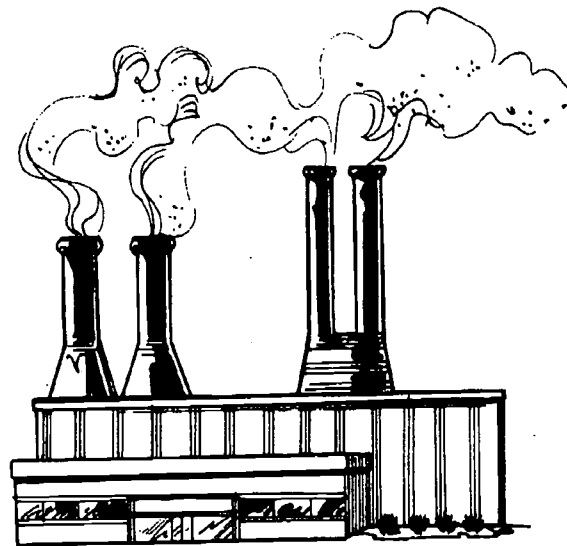
- determine the costs and profits associated with different phases of the manufacturing process
- describe how industrial waste is created
- explain how industrial waste disposal costs can affect product costs.

In this activity, students simulate the interaction of industry and commerce in a role playing activity. They examine the “real” cost of manufactured goods in terms of both economic value and waste management costs.

Materials

Large quantity of paper clips (100 to 200), 3” x 5” index cards, red and black construction paper, rubber bands, scissors, rulers, transparent tape, thumb tacks, shoe boxes, white paper, a paper punch, compass or one-inch circle template, and rubber gloves (optional).

Also *Business Cards* (one card per group) and *Role Cards* (one complete set per group) provided with this lesson.

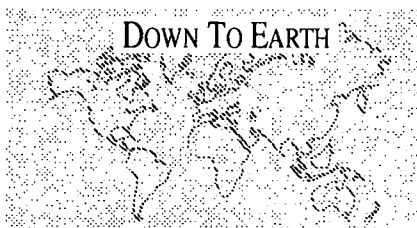


Background

For more information on hazardous wastes, see the Resource section.

Society’s demand for manufactured products seems insatiable. The activities of the manufacturers producing these goods often result in large quantities of industrial waste. Historically, industry’s attitude toward the production of waste has been that it would be too costly to change practices and that any problems created as a result of those practices belong to someone else. Consumers often neglect to realize the “real” price they pay for goods in terms of the hidden costs associated with handling the industrial waste resulting from the manufacture of goods.

In 1995, South Carolina reported generating about 5,847,465 tons of all types of solid waste. The municipal solid waste portion of South Carolina’s waste stream averages about 5.6 pounds per person per day. A large proportion, about half, of the state’s



The federal government is the largest producer of hazardous waste in the United States

Source: *Garbage* magazine. “Toxic Tour of the United States.” July/August 1991

solid waste consists of waste products generated by government, agriculture, manufacturing, business, and industry that provide goods and services to the state's residents and visitors.

During recent years, South Carolina experienced a substantial increase in the number of commercial and industrial businesses in the state. In 1995, approximately 238 new businesses located in the state.

In 1995, about 60 percent of the solid waste generated in South Carolina was buried in landfills, 5 percent was incinerated, 16 percent was recycled, 10 percent was composted, and 10 percent was chipped but not composted, according to S.C. DHEC.

Waste management strategies that could help control the amount of solid waste generated by industries are reduction and reuse. Industries can closely examine their current manufacturing processes and identify ways to reduce the amount of waste generated at each step. In addition, industries can cooperate and find ways to reuse the "waste" products generated by other industries.

In addition to the concerns associated with the amount of solid waste generated by industries in South Carolina, the types of waste generated are also of concern. In order to manufacture the many products consumed by Americans, hazardous materials are often used. Hazardous materials are products or chemicals that pose a significant threat to human health and/or the environment while being transported. Once manufacturing processes are complete, significant quantities of hazardous materials are often left over. These materials eventually become hazardous waste which must be disposed of or managed in some way. In South Carolina, more than 82 million pounds of hazardous wastes are generated by industries each year or are imported to this state from other sources.

Learning Procedure

(Note: Teachers will benefit from practicing this exercise prior to introducing it to the class.)

1. Initiate the activity by asking students to define the term "waste". Make sure students realize that **waste** is anything that is discarded, useless, or unwanted. Next, ask students where waste comes from. Make sure students realize that waste is generated by many sources, including households, businesses and industries, institutions like schools and hospitals, and agriculture.

2. Explain to students that they are going to complete a simulation activity that involves the buying and selling of products of manufacturers and related businesses. Ask students to define the terms "raw material" and "resource." Make sure they realize that **raw materials** are the starting materials for the manufacturing process. Raw materials (such as trees or sand) are still in their natural or original state. **Resources** can be raw materials or previously manufactured materials (such as paper or glass bottles) that can be used to make something else. Emphasize the fact that waste is often generated when resources are used.

3. Divide students into groups of two to three students and assign roles to each group. Make sure each business or industry is represented by the number of groups in parentheses:

- a. Industry A (1-3)
- b. Industry B (1-3)
- c. Industry C (1-3)
- d. Industry D (1-3)
- e. Raw Material Wholesalers (1)
- f. Transporters (2-3)
- g. Wholesale Buyers (1)

Distribute appropriate *Business Cards* to each group. Ask each group to post its business card at its "facility" (table or desk). Distribute a complete set of *Role Cards* to each group.

4. Instruct each group to study its industrial or commercial operation, determine the raw materials and resources required and identify the wastes generated (e.g. excess paper after cutting) if any.

5. Have each group establish its mock industrial or commercial facility at a desk, spreading out black paper to represent buildings and grounds. All work and storage must take place on the paper.

6. Give the group playing the "Raw Material Wholesalers" role all the paper clips, rubber bands, red construction paper, index cards, and thumb tacks. Explain that these are raw materials for the four industries (A-D). Give each group the equipment listed on its role card (e.g., scissors or shoe boxes).

7. Explain that the simulation must begin with Industry A purchasing materials from the Raw Material Wholesalers and arranging with one of the Transporter groups to haul it to the Industry A facility. Using the information given on their role cards, the other industries will each order raw materials or resources from their suppliers (Raw Material Wholesalers or other industries) and arrange for transportation of these materials from the sources to their facilities. The Industry D group(s) will ship the final product to the Wholesale Buyers.

8. Before any buying, manufacturing, or transporting begins, instruct each group to:

- estimate tentative costs for purchasing raw materials, transporting raw materials or products, and disposing of wastes
- estimate the desired net profit from sale of products
- determine the estimated sale price of the product.

Have groups record their estimates on a sheet of paper, a Cost Sheet, set up like the one below.

9. Once all groups have computed cost-profit estimates, let the simulation begin. Tell students that industries should begin production as soon as needed raw materials/resources arrive. Encourage students to identify roles within their groups. For example, the Industry A group could assign one member to meet with raw material suppliers, transporters, and buyers and negotiate costs. Another member could actually make products while a third member keeps inventory and financial records. Remind students that all work and storage must take place on the black construction

If necessary, review a sample cost-profit estimate for Industry A:

Unit cost of raw materials [one unit = (3) 3" x 5" cards and 1 paper clip] = .10 per unit

(3) 3" x 5" cards at .03 each	= .09
1 paper clip at .01 each	= .01

Unit cost of transporting raw materials to facility = .02 per unit

Unit cost of waste disposal (waste = 3 punched holes per unit) = .01 per unit

Total costs per unit = .10 + .02 + .01 = .13 per unit

Desired net profit = .05 per unit + .05 per unit

Selling price = .13 + .05 = .18 per unit

Remind students that they may have to negotiate or revise some of their figures once the simulation begins.

paper. Establish a time limit (35-45 minutes) or product number limit (e.g. 20 complete products) for the activity and remind each group to keep accurate records. *(Note: This activity requires a lot of movement and communication. Circulate among groups to keep them on task.)*

10. At the end of the simulation activity, have groups tally up the total number of raw materials/resources used and determine total costs (for each category) and total profits. Ask each industry to explain its "product" and have groups share their cost/profit figures and describe any problems they encountered.

11. Next, have all groups bring the waste generated by their business or industry to one central location. Distinguish between the terms "hazardous material" and "hazardous waste" and conduct a whole class discussion addressing the following questions:

- What different types of waste were generated?
- How were hazardous materials handled during transport? How much hazardous waste was produced?
- What phases of the product development process generated the most waste?
- How and where can these different wastes be disposed?
- Did any industry recycle or reuse any waste? If so, how?
- How can recycling or reuse of waste save money?
- How can the costs of waste disposal affect the costs of products?
- Who should pay the costs of disposing waste generated by manufacturers?

Be sure to discuss the problems associated with disposing of the hazardous waste generated by Industry C and review the major solid waste management options (reduce, recycle, reuse, recover energy/incinerate, landfill).

Evaluation

1. Collect completed Cost Sheets and examine them for correct cost and profit calculations.
2. Have students write a paragraph summarizing how industrial waste is created and how industrial waste disposal can affect product costs.

Extension Activity

Have a local manufacturer speak to the class about his/her production process, including the raw materials used, products produced, waste generated, and methods of handling the waste generated.

Just Do It

Visit a local manufacturing business or industry in your area. Discuss waste management strategies such as reuse and reduction with business or industry representatives.

Raw Material Wholesalers

Raw Materials: Paper clips, rubber bands, 3" x 5" index cards, red construction paper, thumb tacks (All the raw materials needed by Industries A - D.)

Product: Sales

Shipping Regulations: Red construction paper is a hazardous material and must be shipped between two pieces of folded index card. (Optional: Use gloves when touching red paper.)

Reporting: Keep financial records of what and how much is sold to whom.

Transportation Company

Equipment: Two tractor trailer rigs (Shoe boxes) per company

Raw Materials: None

Product: Transportation

Shipping Regulations: Read industry role cards of customers to determine shipping regulations for each type of cargo.

Reporting: Keep records of every trip, what is hauled, and where it is transported. Keep financial records.

Wholesalers Buyers

Product: Use copies of each industry role card to determine the standard of the product you will get from Industry D. If a delivered product does not meet the standards, do not buy it; communicate to the manufacturer that it is defective and explain the problems.

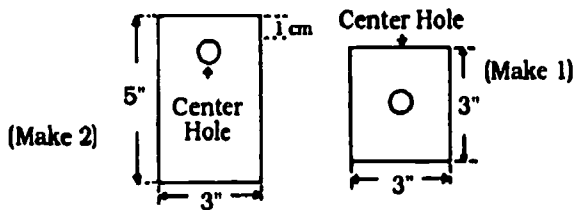
Reporting: Keep financial records.

Industry A

Raw Materials: 3" x 5" cards, paper clips (can be recycled if supplier is found)

Equipment: One paper punch

Product:



Shipping Regulations: Paper clip the three units together to ship.

Reporting: Keep a record of number of products shipped out. Keep financial records.

Buyers: Industry B will buy this product.

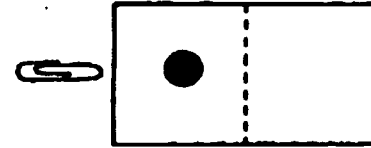
Industry C

Raw Materials: Red construction paper (hazardous material), paper clips, 3" x 5" cards for shipping

Equipment: Scissors, compass, ruler, gloves for handling hazardous materials

Product:

Draw a circle exactly 1" in diameter on red construction paper and cut it out accurately.



Shipping Regulations: Hazardous materials must be shipped in a container. Fold a 3" x 5" index card in half. Place 1 circle inside. Paper clip halves of index cards together.

Reporting: Keep records of products made and shipped. Keep financial records.

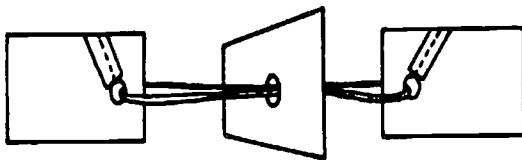
Buyers: Industry D will buy this product.

Industry B

Raw Materials/ Resources: Units produced by Industry A, rubber bands.

Equipment: Transparent tape, scissors

Product: Cut slits in the two rectangular cards, slip in the rubber band, assemble cards as illustrated, tape slits closed.



Shipping Regulations: Ship flat in the truck.

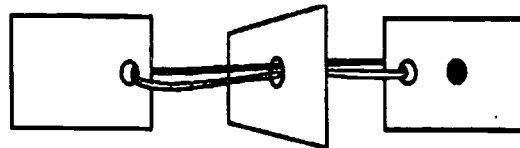
Reporting: Keep a record of number of products shipped out. Keep financial records.

Buyers: Industry D will buy this product.

Industry D

Raw Materials/Resources: Product of Industry B, product of Industry C, thumb tacks or paper fasteners.

Product: Use thumb tack or paper fastener to attach the red circle to the center of one card.



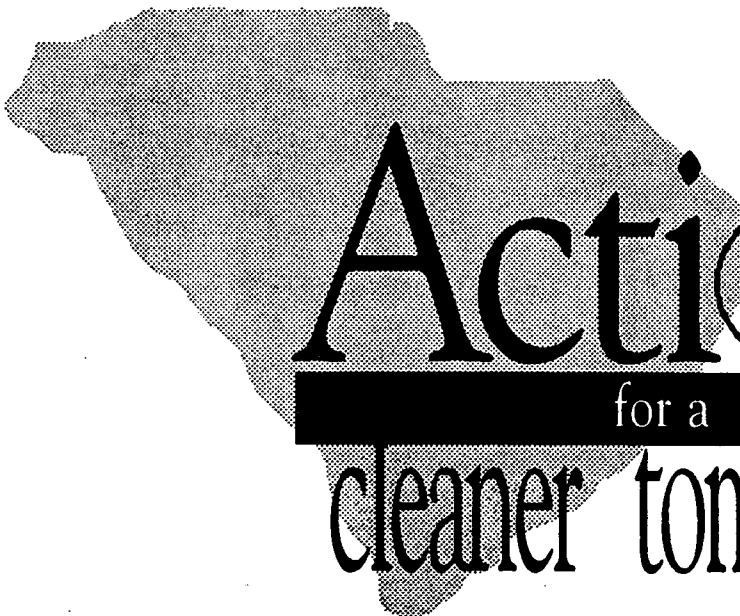
Shipping Regulations: Ship flat on the truck.

Reporting: Keep a record of number of products shipped out. Keep financial records.

Buyers: Wholesale Buyers will buy your product.

Business Cards

Industry A	Industry D
Industry B	Wholesale Buyers
Industry C	Transportation Company
Raw Material Wholesalers	



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South Carolina Department of Health and Environmental Control at
1-800-768-7348.

What's In Those Barrels?

9.LC.4.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

Focus: Regulating and monitoring hazardous wastes.

Subjects: Government, Environmental Science, Speech/Debate

Materials: *Public Hearing* work sheet, student research

Teaching Time: Several class periods, not consecutive

Vocabulary: EPA, RCRA, CERCLA (Superfund), SARA Title III (Emergency Planning and Community Right-to-Know Act), hazardous waste, South Carolina Department of Health and Environmental Control



Learning Objectives

Students will:

- describe the major functions of governmental agencies that regulate or monitor hazardous substances
- explain acts of Congress concerning hazardous waste
- discuss the role of a public hearing in a democracy.

In a whole class setting and in small groups, students investigate governmental agencies involved in hazardous waste management and conduct a simulated public hearing.

Background

Prior to World War II, there were no environmental regulatory programs. States directed their efforts to land use – not to issues of land quality.

After World War II, technological advances contributed more to waste generation than to waste disposal. In 1970, the establishment of the U.S.

Environmental Protection Agency (EPA) and amendments to the federal Solid Waste Disposal Act of 1965 were important steps toward addressing current issues in waste disposal methods. Emphasis began to shift from waste disposal to waste management and resource recovery.

Hazardous waste and its disposal received major attention with the passage of the **Resource Conservation and Recovery Act (RCRA)** in 1976. This act, which replaced the Solid Waste Disposal Act, controls hazardous waste by setting standards for hazardous waste disposal and tracking hazardous waste from generation to disposal. The 1980 **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)** or **Superfund** reflected changing attitudes and

DOWN TO EARTH



A proposed Japanese government "Green Code" encourages Japanese businesses operating abroad to adopt environmental protection measures that are tougher than the host country requires.

Source: 1993 *Environmental Almanac*

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increasing efforts to protect the nation's land and water from further hazardous waste contamination. Many different government agencies are now involved in hazardous waste management activities.

The \$1.6 billion Superfund program was created to pay for cleanup of the worst hazardous waste sites in the nation. According to the *1994 Environmental Almanac*, "as of June 1993, the Superfund program had cleaned up only 161 hazardous waste sites, but another 1,256 sites remain on the National Priority List. The program has already cost \$15 billion. Cleanup per site has cost \$30 million on average. Estimates for the total cleanup bill, to be tallied decades from now, have varied from \$750 billion up to \$1.5 trillion. The vast range occurs because the federal legislation that sets the nation's priorities on hazardous waste, especially CERCLA and RCRA, established cleanup programs other than Superfund. These cover an estimated 4,000 former dump sites that must be cleaned up by states or private organizations. In addition there are as many as 2.7 million underground storage tanks containing petroleum or chemical products that need to be removed."

In 1994, in South Carolina, over 1,000 petroleum tank systems were excavated and found to be leaking.

Waste is classified as **hazardous waste** if it is dangerous to human health and/or the environment. RCRA categorizes hazardous waste into four groups: toxic (poisonous), reactive (can explode or react violently if exposed to air or water), ignitable (able to catch fire), and corrosive (gradually dissolves other materials or containers).

Toxic chemicals and materials – used in manufacturing and in a variety of service industries such as dry cleaning – are literally everywhere. Tens of thousands of such chemicals and materials are used by industry in the manufacture of consumer goods. In other words, to say that hazardous waste is a byproduct of industry is true but a little misleading. Hazardous waste is *our* byproduct as a society. It is the byproduct that comes from producing the things that *we* buy, the things that *we*

decide to purchase. For without market demand for goods, there would be no need for industry to produce them.

Hazardous waste is not just a byproduct of excess consumerism. Hazardous waste is generated when our medicines are made and when our homes are built. While reducing the generation of hazardous wastes is important and the improved management of hazardous wastes is critical, our society – as we know it, with cars and televisions, and microwave ovens and clothes (even 100 percent cotton pieces) – will always have hazardous wastes to manage.

While toxic emissions and wastes may be very small compared to the emissions of conventional pollutants, their effects can be extremely hazardous to human health as well as damaging to plants and animals.

Public pressure and media attention to the problems caused by hazardous waste and improper hazardous waste disposal have motivated local leaders to take a hard look at toxic substances and to move to reduce hazardous waste in their communities.

According to Michael Brown, associate professor of international health at the Harvard School of Public Health and author of *Toxic Politics: Responding to Chemical Disasters*, "communities concerned with hazardous waste soon discover that toxic pollution is not simply a technical problem, not simply a problem of information, but is a deeply rooted political problem involving the distribution of power in our society."

The public gained a window into the toxic waste picture in America in 1986 when the **Emergency Planning and Community Right-To-Know Act** went into effect. The law is known as Title III of the **Superfund Amendments and Reauthorization Act (SARA Title III)**. The law requires companies with nine or more employees to detail their releases of any of 313 listed toxic chemicals and chemical compounds to air, water, or underground wells. The report is used to compile a national **Toxics Release Inventory**.

The Toxics Release Inventory quickly became a valuable source of environmental data, useful to citizens, the press, regulators, lawmakers, and to industry itself.

The 1987 Toxics Release Inventory was the first time that this data had been collected in a way that provided an overall picture of company emissions. Now, because of the awareness caused by the report and pressure from community groups, many manufacturers are taking steps to cut emissions.

Learning Procedure

1. **Ask:** What is hazardous waste? Where should hazardous waste disposal facilities be located? (*This should lead to some debate or a pronouncement to have them somewhere away from your local area. This is the NIMBY or Not-In-My-Backyard syndrome.*)

Ask: Who should decide where hazardous waste disposal facilities can be located, and who should set the regulations for how these facilities are operated?

Review with the group the congressional acts and primary state and federal agencies (RCRA, CERCLA, **South Carolina Department of Health and Environmental Control** and U.S. EPA) related to hazardous waste regulation and disposal. Review the definition and categories of hazardous waste and present the background information. See the Resource section on Hazardous Waste, as needed.

2. Divide the class into eight small groups and instruct each group to research one of the following government agencies involved in the enforcement of hazardous waste legislation:

- a. U.S. Environmental Protection Agency
- b. U.S. Department of Energy
- c. U.S. Army Corps of Engineers
- d. U.S. Department of Labor
- e. U.S. Department of Transportation
- f. U.S. Department of Health and Human Services
- g. U.S. Interstate Commerce Commission
- h. South Carolina Department of Health and Environmental Control.

Explain that each group should research, write, and present a brief report that includes the name of the agency, its responsibilities, and the government legislation (if any) for which the agency is responsible.

3. For the students researching DHEC, you may want to point them to the Bureau of Solid and Hazardous Waste Management, 2600 Bull Street, Columbia, South Carolina. This office publishes a report annually titled, *Hazardous Waste Activities Reported in S. C.*

4. After each group has presented its report, tell students they will investigate the roles of local citizens and elected officials in the management and disposal of hazardous waste. A mock public hearing will be conducted and students will act out various roles.

5. Distribute copies of the *Public Hearing* worksheet. Review the scenario and questions, and assign each student to one of the four roles.

6. Set the date for the hearing, and let students prepare for their roles. Have them gather information to use in support of their positions at the hearing. Suggest that students contact their counterparts in the community for insight into the situation from those persons' perspectives. Be sure they pay particular attention to the "Questions for Consideration" on the worksheet.

7. Select a principal hearing officer to moderate and conduct the hearing. Review the points presented and review the "Questions for Consideration."

Just Do It

Learn the facts.

Spread the word that there are proper and legal ways to dispose of wastes and that we must accept the responsibility for properly managing wastes.

Attend public hearings on siting issues.

Ask questions.

Listen to all points of view.

Decide what is best for your community, the state, public health, and the environment.

Make your voice heard!

8. Have a class vote to determine whether or not ACME, Inc., the company presented in the scenario, should receive its permit.

Questions for the Class (following hearing)

1. What do you think the response would be to the proposal to locate a hazardous waste disposal site in your neighborhood?
2. How has researching of this issue affected your attitude toward hazardous waste management?
3. How can you, as a citizen, influence legislation, regulation, and monitoring of hazardous wastes?
4. Describe the major function(s) of at least three of the following governmental agencies in regulating or monitoring hazardous materials, or waste:
 - U.S. Environmental Protection Agency
 - U.S. Department of Energy
 - U.S. Department of Energy
 - U.S. Army Corps of Engineers
 - U.S. Department of Labor
 - U.S. Department of Transportation
 - U.S. Department of Health and Human Services
 - U.S. Interstate Commerce Commission
 - South Carolina Department of Health and Environmental Control.
5. Describe RCRA and CERCLA.
6. Write a paragraph explaining why a public hearing is important in a democracy.

Extension Activities

1. Invite representatives from the community who would be involved in a similar real-life situation to speak to the class. Compare the guests' descriptions of their roles to their portrayals by the class members. Some questions might include the following:
 - Does the guest feel that local companies are responding properly to the problems of hazardous waste?
 - How do the answers by representatives of

local companies compare with those by representatives of agencies?

- Where are hazardous wastes being generated in your community?

2. Contact appropriate local and/or state agencies and find out how hazardous wastes in the community are managed and where they are disposed and/or treated.
3. Have students interview a foreign exchange student to inquire about issues and handling of hazardous waste in their countries.
4. Have students select a local company and inquire about hazardous waste reporting and where hazardous waste goes for disposal and treatment.

For More Information About Wastes

Working Notes, a newsletter covering right-to-know about toxic pollution. (\$15 per year) The Working Group is hosted by the U.S. Public Interest Research Group Education Fund, 215 Pennsylvania Avenue, SE, Washington, DC, 20003-1155. (202) 546-9707.

Other sources include:

U.S. EPA's Toxic Release Inventory User Support Service. This service helps citizens locate and access TRI data. (202) 260-1531, FAX (202) 260-4659

"Pocket Guide for Chemical Hazards," National Institute for Occupational Safety and Health, 1990. Helps citizens identify TRI chemicals under various common names. (800) 35NIOSH.

The Scenario

ACME, Inc. has applied for a permit to dispose of its hazardous waste in a secure landfill to be built at a designated site in the community. Citizens in the community are concerned about the proposed location of the site and the potential dangers of such a facility. A public hearing has been scheduled.

Questions for Consideration

1. What state and federal agencies are responsible for the regulation and management of hazardous waste? What permits are necessary for a hazardous waste treatment facility/disposal site? What specific information must be sent to the regulatory agencies in order to apply for a permit? What criteria are used by regulatory agencies to determine if a disposal facility is being operated in an appropriate manner? Who will operate the disposal facility?
2. Do local planning and zoning restrictions affect the location of hazardous waste disposal sites? What are the local regulations for transporting hazardous waste? What type(s) of hazardous wastes will be disposed at this site? What makes waste hazardous?
3. Has the corporation (ACME, Inc.) adequately addressed the needs of the local citizenry? How?
4. Is there a process available that will make the waste nonhazardous?
5. Have emergency response plans been developed for spills, leaks, accidents, etc.?
6. What happens in the event of non-compliance?

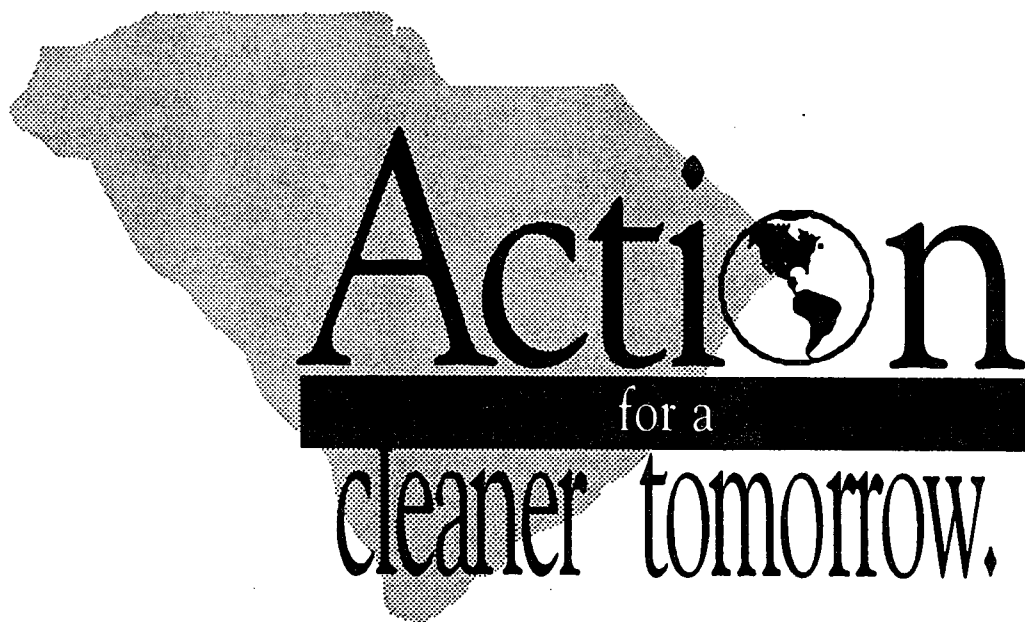
Roles

Concerned Citizens Group - The designated disposal site is near a large housing development. Concerns include: (a) possible contamination of the adjacent land, (b) depreciation in the value of homes, (c) health risks from spillage by trucks transporting waste, (d) damage to roads because of increased truck traffic, and (e) safety risks from increased commercial traffic.

County Engineer & City Officials - Responsibility for the design of the disposal site is one that has been taken seriously. Defense of the site selection includes: (a) site selection was made after evaluating all possible locations; (b) compliance with county, state, and federal regulations has been of prime importance; (c) advice on all technical aspects of the design has been sought; and (d) from the beginning, local commissioners have been kept informed of all the details.

ACME, Inc. Attorneys & Officials - Confidence in the safety of the hazardous waste disposal site is based on: (a) proven safety features having been designed for this site; (b) records, data, graphs, and depositions from other communities where this company is located are available; and (c) compliance with all county, state, and federal regulations can be documented.

Three Hearing Officers from the South Carolina Department of Health and Environmental Control - The purpose of this hearing is to gather information from all the parties involved. Findings are reported to state officials. The principal officer, a state official, moderates the hearing.



Action

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cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

How Very Little It Must Be

9.HW.8.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 11 – 12

Focus: Drinking water and ground water

Subjects: Chemistry, Math, Environmental Science, Communications

Materials: *How Very Little It Must Be* work sheet, calculator (optional)

Teaching Time: One class period

Vocabulary: Parts per million, parts per billion, drinking water, ground water

While the measurements parts per million (ppm) and parts per billion (ppb) are widely used in studying environmental contamination, the size of these measurements can be difficult to visualize.

Learning Objective

Students will:

- working from data, gain experience calculating ppm and ppb
- understand how proportionally small a ppm and a ppb are
- understand that very little of some contaminants goes a long way.

Background

See the Resource section for more information on hazardous wastes.

Learning Procedure

1. Some environmental contaminants are so hazardous that we need to measure them in terms of ppm or even ppb. What do these terms mean?

When you take a look at the Earth's water and the amount available, it's easy to understand why protecting it is important.

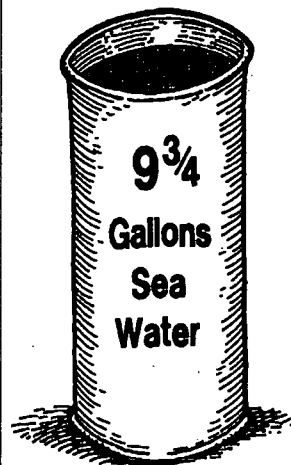


4 1/2 Cups

Total Fresh Water

1/2 Cup

Accessible Fresh Water



8 1/2 Drops

Available & drinkable in ground water



1/2 of a Drop

Available in unpolluted lakes, reservoirs, etc.

The Earth's Water = 10 gallons

A ppm is a proportion in which one unit of a substance is found in a million units of surrounding material such as air, soil, or water. One ppm is proportional to one second in twelve and a half days (300 hours).

A ppb is a proportion in which one unit per billion is measured. One part per billion is proportional to one second in 32 years.

2. Provide students with the following information:

- **Clear Lake** is a 100-acre lake, with an average depth of 25 feet.

DOWN TO EARTH

Americans use 2 1/2 times as much water per person as a Japanese citizen, and nine times as much water as someone from Great Britain.

9-12
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- **Swimming Pond** covers one acre, with an average depth of 10 feet.
- **Deep Rock Aquifer** extends more than 50 square miles, with an average depth of six feet.

Drinking Water Standards

Listed here are some of the chemicals or compounds that can contaminate our drinking water, along with the federal standards for the *maximum acceptable levels* allowed in both ppm and ppb.

Benzene - 0.005 ppm = 5 ppb

Arsenic, Lead - 0.05 ppm = 50 ppb

2,4-D (a weed killer) - 0.10 ppm = 100 ppb

1,1,1-Trichloroethane (TCE) -

0.2 ppm = 200 ppb

Fluoride - 4 ppm = 4,000 ppb

Conversion Table

1 cubic foot = 7.48 gallons

1 gallon = 0.1337 cubic feet

1 acre = 43,560 square feet

1 square mile = 27,878,400 square feet

3. Using the information above, have students solve the following problems. (*Answers are given here in parenthesis*)

- The EPA Criminal Investigations unit is attempting to track down the parties responsible for dumping five gallons of the herbicide 2,4-D in Swimming Pond. If the chemical becomes evenly dispersed, what would be its concentration in ppm? (*1.534*) In ppb? (*1,534*) **Ask:** Should the U.S. EPA restrict access to Swimming Pond? Why?

- The State Highway Patrol has notified the Department of Health and Environmental Control that six gallons of benzene were accidentally spilled into Clear Lake. If it is evenly dispersed, what would its concentration be in ppm? (*0.00738*) In ppb? (*7.38*) **Ask:** Should the residents who depend on the lake for drinking water be notified? Why?

- An old rusted, unmarked 55-gallon drum was discovered on the property of a resort near Clear Lake. Although the manager suspects it may contain a hazardous chemical, he asks his assistant to get rid of it any way he can. Calculate the concentration of contaminant in ground water if a 55-gallon drum of the chemical were illegally disposed in an old well and dispersed evenly throughout Deep Rock Aquifer. (*0.000879 ppm or 0.879 ppb*) **Ask:** What if the same quantity of the chemical were illegally disposed of in Clear Lake? (*0.0675 ppm or 67.5 ppb*) In Swimming Pond? (*16.9 ppm or 16,900 ppb*)

NOTE: Concentration is one issue. The type of chemical a given concentration is what is important. In this scenario, we are not told the type of chemical spilled. Are any of these concentrations within safe limits for any of the maximum acceptable levels provided? For example: in Deep Rock Aquifer, all chemicals listed are acceptable at the concentrations in the example. In Clear Lake, some are and some are not. In Swimming Pond, none are acceptable ... at these concentrations.

- Suppose a 5,000-gallon tank truck loaded with the chemical arsenic ran off the highway and all the chemical spilled into Clear Lake. What would be the concentration of chemical in the lake? (*6.138 ppm or 6,138 ppb*) **Ask:** Does this violate federal standards?

4. Have students compare their calculations to the federal drinking water standards for all the chemicals listed above. **Ask:** Which "incident" was the worst in terms of contamination? Which scenario(s) didn't violate any of the standards? How many of the cases violated the benzene standards? The TCE standard?

5. Discuss possible ways of dealing with each of these problems. (*calling the South Carolina Department of Health and Environmental Control; determining civil or criminal penalties for violators – the Pollution Control Act allows fines up to \$10,000 per day per violation for polluters; educating the public as to potential threats to*

human health and to fish and wildlife; restricting access to contaminated waters; developing plans to prevent similar contaminations in the future, etc.)

Extension Activities

1. Have students research the chemicals used above as to their industrial or household uses and potential health hazards.
2. If you have access to a computer, have students use a spreadsheet or write a short computer program that calculates the answers to the problems above.
3. Have students discuss the issues related to informing the public about environmental contamination.
 - Does the public have a right to know about all instances of environmental contamination? Why or why not?
 - What is the best way to inform people of a contamination incident?
 - Who should be told? When?
 - In how wide an area should the information be distributed?
 - Who should be responsible for notifying the public?
 - What are the impacts of releasing this information? (affects on property values, hysterical reactions, etc.)

How would students handle the public information for the three scenarios included with this lesson? Have them write sample press releases and plan their distribution, including media outlets within a geographic region and timing. Have students research the public information rules and regulations followed by the South Carolina Department of Health and Environmental Control and the Freedom of Information Act. Invite a representative from S.C. DHEC to talk to the class. Call 1-800-SO-USE-IT or write:

S.C. DHEC
Office of Public Information
2600 Bull Street
Columbia, South Carolina 29201

4. Have students create their own examples or illustrations that describe the ppm and ppb measurements.

How Very Little It Must Be

1. The EPA Criminal Investigations unit is attempting to track down the parties responsible for dumping five gallons of the herbicide 2, 4-D in Swimming Pond. If the chemical becomes evenly dispersed, what would be its concentration in ppm? In ppb? Should the U.S. EPA restrict access to Swimming Pond? Why?

2. The State Highway Patrol has notified the S.C. Department of Health and Environmental Control that six gallons of benzene were accidentally spilled into Clear Lake. If it is evenly dispersed, what would its concentration be in ppm? In ppb? Should the residents who depend on the lake for drinking water be notified? Why?

3. An old rusted, unmarked 55-gallon drum was discovered on the property of a resort near Clear Lake. Although the manager suspects it may contain a hazardous chemical, he asks his assistant to get rid of it any way he can. Calculate the concentration of contaminant in the ground water if a 55-gallon drum of the chemical were illegally disposed of in an old well and dispersed evenly throughout Deep Rock Aquifer.

What if the same quantity of the chemical were illegally disposed of in Clear Lake? In Swimming Pond?

4. Suppose a 5,000-gallon truck loaded with the chemical arsenic ran off the highway and all the chemical spilled into Clear Lake. What would be the concentration of chemical in the lake? Does this violate federal standards?

Drinking Water Standards

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Fluoride - 4 ppm = 4,000 ppb

Conversion Table

1 cubic foot = 7.48 gallons

1 gallon = 0.1337 cubic feet

1 acre = 43,560 square feet

1 square mile = 27,878,400 square feet

Water Body Dimensions

Clear Lake - 100-acre lake, 25 feet deep

Swimming Pond - 1 acre, 10 feet deep

Deep Rock Aquifer - 50 square miles, 6 feet deep

Making Acid Rain

9.IN.2.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

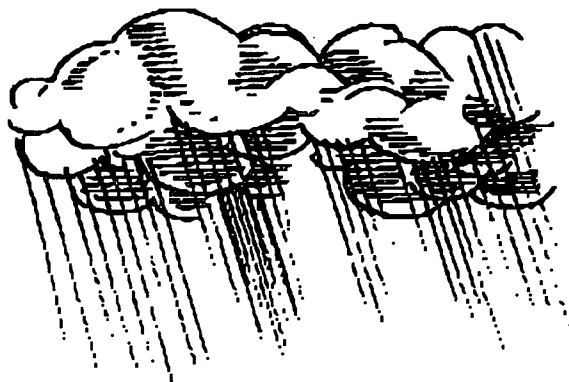
Focus: Understanding acid rain

Subjects: Environmental Science, Chemistry, Biology

Materials: See list of materials itemized below

Teaching Time: Two or three class periods including discussion

Vocabulary: Acid rain, acid anhydrides, incineration



Learning Objective

Students will:

- learn that burning nonmetals produces oxides called acid anhydrides that, when combined with water, form acids. As gases, acid anhydrides may dissolve in rain to form acid rain
- understand the potential harm to the environment from acid rain
- see how scientific information is used in making decisions about waste management.

Caution: This activity produces SO_2 . Use proper safety precautions.

Materials

See *Lab Instructions* sheet. For the safety of the class, the experiment should be performed in a lab with a hood and a fan to preserve air quality. It is possible to do this outside.

Background

Incineration reduces the volume of wastes to be disposed, but poses problems including the production of acid gases that can contribute to acid rain. Other sources of acid gases introduced into the

Acid rain forms when sulfur dioxide or nitrogen oxides combine with water droplets in the atmosphere to form highly corrosive acids. Over time, acid precipitation can increase the acidity of lakes, streams, and soils so much that local ecosystems are severely damaged. Acid rain can also contribute to forest blight.

atmosphere include automobile exhaust and emissions from coal-fired electricity generating plants. U.S. EPA-required devices such as catalytic converters for cars, and scrubbers for power plants and incinerators remove most of the harmful gases and heavy metals from these emissions.

Questions for the Class

1. What causes acid rain? How is acid rain formed?
2. What are the physical and chemical differences between the products of incinerated metals and incinerated nonmetals?
3. What are two sources of toxic acid gases from burning unsorted garbage? (*Hydrogen chloride can*



Virginia's St. Mary's River is number 10 on the list of Top 15 Threatened Rivers of 1993 (this is a worldwide listing). The river's threat is listed as acid rain.

Source: 1994 *Environmental Almanac*

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be released from burning plastics. Sulfur dioxide is formed when sulfur-containing substances are burned.)

4. What are three effects of acid rain on the environment?

Learning Procedure

1. Tell students this experiment will investigate the burning of nonmetals such as might occur in the **incineration**, or burning, of garbage. Explain that although incineration is already being used by some 70 cities and counties in this country as well as by many European countries, there is concern that gases emitted from such operations have the potential to cause environmental harm.

2. Tell students this experiment will investigate the release of **acid anhydrides** from the burning of nonmetals that might be part of the refuse burned in an incinerator. Explain that acid anhydrides such as sulfur dioxide and nitrogen oxides are a source of acid rain. Acid rain has been linked to fish kills and destruction of forests, as well as damage to microorganisms that are vital to our environment.

3. Have students work in pairs. Hand out the *Lab Instructions* sheet. Go over the laboratory procedure with the students.

4. Have students do the experiment and answer the questions on the lab sheets.

5. When all the students have finished, **ask**: What does this demonstration show us about how acid rain is formed? What is the potential relationship between waste and acid rain?

6. **Ask**: How might the acid gas emissions from waste incinerators be controlled? (*Neutralization of the acids with an appropriate base.*) Explain that the best incinerators are equipped with devices called scrubbers.

In South Carolina, scrubbers are required to meet with air emission standards. As refuse is burned, the

gases released are mixed with a lime (calcium oxide) and water solution that is sprayed into the chimney flue. The lime slurry neutralizes the acid gases to nontoxic calcium salts. At present, most incinerators in this country are not equipped with scrubbers.

7. Discuss with students some of the other processes that contribute to acid rain. (*Auto exhaust produces nitrogen oxides; coal-fired electric generators and many smelters produce sulfur dioxides.*) **Ask**: What are some natural sources of acid rain? (*carbon dioxide*)

Extension Activities

1. Have students research the causes of acid rain in the U.S., the areas most affected, and the effects on the environment.

2. Determine which acids could be formed from burning the following: nitrogen, phosphorus, and carbon. Which would be the most acidic?

3. Invite a speaker from the South Carolina Department of Health and Environmental Control or your local municipal engineering department to speak on incinerators and waste management problems.

Acknowledgment

Parts of this experiment are based on material from Educators for Social Responsibility. Investigations: Toxic Waste (a science curriculum) Boston Area Educators for Social Responsibility: Cambridge, MA, 1984.

MAKING ACID RAIN

Name _____

Date _____

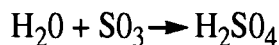
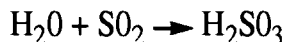
Introduction

Both federal and state governments now impose strict requirements on the disposal of wastes in landfills. Many municipal governments faced with the closing of old dumps are considering incineration to be an attractive alternative. Incinerators not only reduce the volume of garbage disposed, they also generate heat that can be used to generate electricity if the incinerator is designed as a waste-to-energy facility. However, there is a great deal of concern about the potential for environmental harm.

The burning of nonmetals produces oxides called acid anhydrides that form acids when dissolved in water (acid rain). This occurs when acid anhydrides escape into the air as a byproduct of combustion in plants such as smelters, coal-fired electric generating stations, and incinerators. Acid anhydrides dissolve in rain water, decreasing the pH of the rain and this is called acid rain. Burning plastics can release hydrogen chloride gas that is also very acidic when dissolved in water. Acid rain has been linked to fish kills, the dying off of forests, and the destruction of microbes that are vital parts of our ecosystem. Damage to statues and concrete buildings that contain limestone (calcium carbonate) has also been reported. For example, the Statue of Liberty was recently restored to partially reverse the effects of pollution and acid rain.

The burning of metals produces oxides called basic anhydrides that form bases when dissolved in water. Basic anhydrides are mostly solids. So when metals are incinerated they produce solid basic anhydrides, some of which end up as particulates in incinerator fly ash. Many heavy metals are toxic or carcinogenic when ingested over a long period of time.

Naturally occurring substances such as carbon dioxide have always caused rainwater to be slightly acidic. The dilute solution of carbonic acid that results means that most rainfall has a normal pH of around 5.6. Rain water with a pH of 5.5 or lower is considered to be acid rain. In the northeastern United States, the acid anhydrides of sulfur and nitrogen emitted from a variety of sources have lowered the pH of rainwater to around 4.0 to 4.5. Sometimes a pH as low as 3 has been observed. (Orange juice has a pH of around 4.5; a pH of 3 is about that of vinegar.) The main reactions are:

**Materials**

Goggles
Fume hood (or could be performed outdoors)
Sulfur flowers or powder
Gas bottle - size 100 ml
Deflagrating spoon (or could use test tube)
Cover plate (glass plate)
Litmus paper and pH paper

Stirring rod

Magnesium ribbon
Chalk
Test tube
Paramecium or Euglena (or mixed) culture in solution
Microscope slides
Microscope

Procedure

1. Pour about 1.25 cm (1/2 inch) of distilled water (10 ml) into a gas bottle. Place a BB-sized amount of sulfur in a deflagrating spoon and start it burning. Ignite sulfur in a fume hood, to protect students from fumes.

2. Quickly lower the spoon into the gas bottle near the water. Cover the mouth of the bottle as much as possible to prevent the escape of the SO_2 gas being produced. (See Illustration.) Option: use Ziplock bags to collect the SO_2 .

3. When the sulfur has burned completely, remove the spoon and cover the top completely to trap the SO_2 gas.

4. Shake the bottle for about a minute to mix the SO_2 and water. (Be certain the cover is securely in place before shaking the bottle.)

5. Using a stirring rod, place a drop of distilled water on pieces of red and blue litmus paper and on a piece of pH paper. Record your observations.

Red litmus paper _____ Blue litmus paper _____ pH = _____ of distilled water.

6. Extract about 2 ml of "acid rain" from the bottle into a test tube. Repeat the above tests on this sample. Record your results.

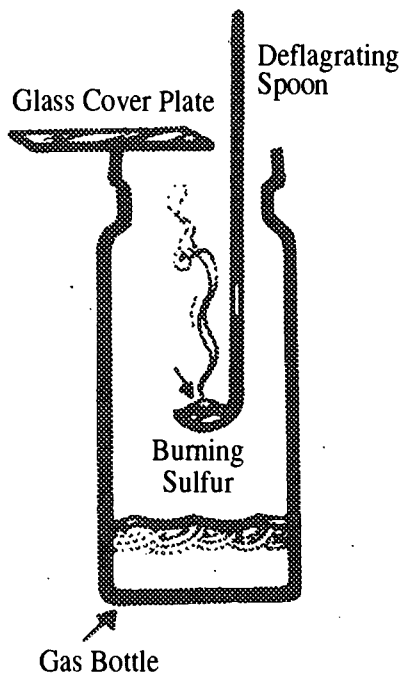
Red litmus paper _____ Blue litmus paper _____ pH = _____ of "acid rain" water.

7. Place a drop of culture (Paramecium or Euglena or mixed) on a microscope slide. Examine it under the microscope for three minutes. Record your observations. (Use a separate piece of paper if necessary.)

Add three drops of "acid rain" to the slide. Be sure the drops fall evenly over the original drop. Observe the effects under the microscope for three minutes and record your observations.


8. Place a 1 cm length of magnesium ribbon into the test tube. Observe it for at least three minutes. Record your observations. Repeat this experiment with a piece of chalk. Record your observations.

9. (Optional) Repeat Step 7 with salt solutions of varying concentrations. Repeat Step 7 using stock solutions of acid of varying concentrations. Record your observations for each different pH and salt concentration.



Follow-up Questions

1. What is the equation for the burning of sulfur in air?
2. How was the acidity of the water affected by the gas produced from the burning of the sulfur?
3. What happened to the bacteria culture when the "acid rain" was added. What might happen to a small lake or pond if such a solution were added over a long period? What kind of lakes might be more affected than others?
4. If a liquid similar to our "acid rain" solution was allowed to stand on a marble statue or the steel supports of a bridge, what effects would you predict?
5. Is pH a good predictor or indicator of water contamination?
6. What other information or scientific data might you want to answer questions three through five?



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

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South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Making Landfill Models

9.LA.1.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: Leachate and landfills

Subjects: Chemistry, Environmental Science, Math

Materials: See list of materials below

Teaching Time: Three to four class periods per procedure (not consecutive), homework, one month (minimum) for leachate collection

Vocabulary: percolate, residue, leachate, aquifer, groundwater

Note: This lesson includes construction of a landfill model. It is not necessary to purchase new items for most of the materials listed. Enlist the support of parents and students in providing materials. This is a long-term project and could involve several classes.

Learning Objective

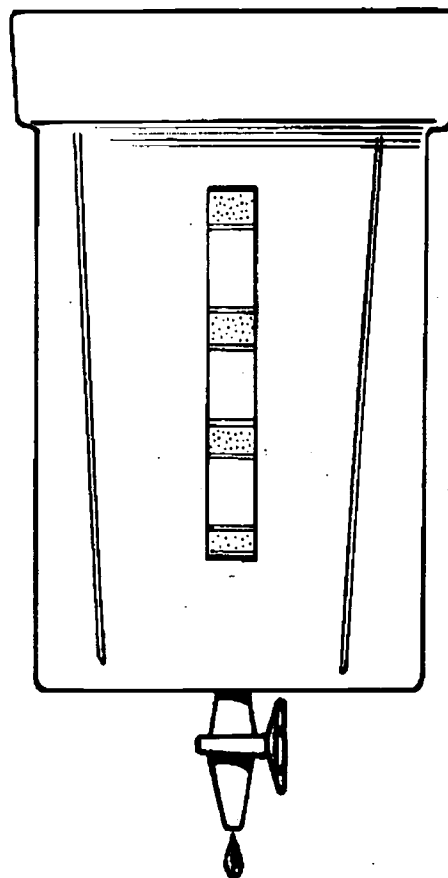
Students will:

- define waste and leachate
- describe a sanitary landfill in terms of its construction and function
- identify some common chemical and physical properties of leachate
- describe the effects of leachate on soil and groundwater.

Background

For more information on landfills and state and federal landfill regulations, see the Resource section.

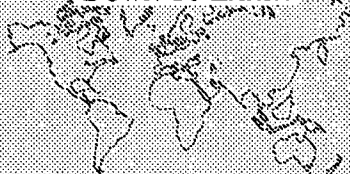
Landfills bury waste. An important factor in how landfills are built is how they contain waste and prevent waste from contaminating nearby soil and



water sources. The possibility of leachate contaminating soil and groundwater exists wherever wastes are disposed. **Leachate** is formed in landfills when disposed fluids mix with water (from precipitation) infiltrating through the soil covering. This water **percolates** through the waste, picking up a variety of suspended and dissolved materials from the waste. It collects at the bottom of a landfill.

In unlined landfills, the leachate continues to leach into the ground. Some landfills have a simple clay liner used for containing leachate. In these landfills, which are being closed, leachate is not collected for treatment. In landfills with more sophisticated liner

DOWN TO EARTH



In 1992, San Diego officials excavated portions of a closed city landfill. They found an entire newspaper from 1959, still intact and still readable. "Death Knell Tolls for Rock 'n' Roll," read the headline of an article claiming that the music was going the way of the dance the Charleston.

Source: *Waste Age*, July 1992

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systems, Subtitle D landfills, leachate is collected and treated.

In this lesson, the landfill model represents the construction of a Subtitle D sanitary landfill to hold municipal solid waste.

Materials

(Note: The diagram provided with this lesson and materials list below call for a 30-gallon garbage can. Some teachers have chosen to modify this by using a 13-gallon kitchen trash. Before you select to use the smaller can, please be aware that a larger can will provide for a greater selection of trash to be placed in your "landfill," allowing you to collect a "better" quality leachate for your experiments. However, the larger trash can will require a greater amount of "rain" and more percolation time for leachate collection.)

- plastic garbage can (30-gallon)
- clear Plexiglas, $\pm 4'' \times 30''$ (Be sure to modify this if you choose to use the 13-gallon kitchen trash can.)
- 5 to 10 gallons of soil
- screw-in, plastic faucet with securing nut
- a small piece of screened wire, $\pm 2''$ square
- caulking compound
- waterproof glue for plastic
- one gallon of distilled water
- (optional) coliform bacteria test kit/lactose broth
- laboratory thermometer
- student work sheets (included)

Learning Procedure

1. Discuss with the students the following questions:

- What is waste?
- What does the term "biodegradable" mean? *(Please read the Resource section on Composting for a discussion on biodegradation. Note that all the elements for biodegradability – air, water, and sunlight – are not available in a landfill. Without air, water, or sunlight, there is no degradation.)*

- What are the sources of waste? Give examples.
- What happens to the waste from our homes, schools, and businesses? Then what? Then what? *(Lead the students to the conclusion that most waste is buried in a landfill.)*
- Why is waste disposal an important issue?

2. If possible, make arrangements for students to visit the nearest landfill site, or arrange a presentation by a local waste management or public health expert. Explain to the students how a landfill is constructed. Discuss:

- site selection
- methods and operations
- chemical and biological reactions occurring in completed landfills
- methane gas and leachate movement and control
- landfill design criteria and regulations.

3. Ask the students to describe what they think the properties of landfill leachate might be *(in terms of pH, bacteria, and suspended solids)* and what the processes occurring in its formation might be. *(Seeing the landfill operation or hearing a presentation by a landfill operator first will give students a better understanding of the simulation they will be undertaking. As a less-than-complete-but-effective alternative, have the students take a trip to the school dumpster which should reveal the early formation of leachate as liquid wastes have probably started to accumulate in the bottom of the container.)*

4. Ask each student to bring to class a small plastic bag containing household wastes, including foodstuffs (vegetable and fruit peels, NO meat or dairy products), yard trimmings or plant residue, metal, paper, plastic, and cloth. As they bring the small bags of waste, have them deposit the bags in a larger bag or other large container.

5. Have the materials and equipment gathered for constructing the landfill model. *(See the student sheet: Construction of a Sanitary Landfill Model, included.)* Divide the class into teams.

Give the teams copies of the student sheet, *Construction of a Sanitary Landfill Model*, and proceed with the landfill model construction and waste preparation.

6. To prepare for the simulated rainfall, determine the average annual precipitation for your geographic area. Information is available from the state climatologist or local Clemson extension agent.

7. Divide the average annual precipitation by 52 to calculate the average weekly precipitation.

8. Measure distilled water to equal the amount of the calculated average weekly precipitation and sprinkle it over the soil in the model landfill.

9. Repeat the addition of “average weekly precipitation,” keeping a record of the number of “weeks,” until water begins to collect in the bottom of the model landfill. (*The liquid that collects in the bottom is the leachate.*) Be prepared to allow several weeks of adding precipitation to obtain enough leachate to perform this activity.

10. Monitor the temperature by inserting a thermometer as far as possible into the center of the landfill model and keeping a daily record of temperature readings. This can be an excellent graphing exercise.

11. One month after the addition of the water, withdraw all of the leachate from the model and test for pH, total suspended solids (liquid weight minus weight of solids), hardness, coliform bacteria (optional), and other water quality factors for which tests are available.

- a. Compare the results of these tests with the properties of distilled water and graph the results.
- b. Discuss what we can do to prevent leachate from contaminating **groundwater** and surface waters.

Explain to the class that leachate contamination can be controlled through landfill design—for example, landfill liners and leachate collection systems help to control contamination.

Extension Activities

1. How Leachate Contaminates Groundwater

To determine how leachate, once it has reached an aquifer, contaminates groundwater, conduct the following experiment:

Materials Needed:

- 4 petri dishes
- 4 steel nails
- soap
- rubbing alcohol
- paper towels
- universal indicator paper
- a sample of the leachate
- household ammonia
- household vinegar
- tap water
- safety goggles

a. Measure the acidity of the leachate with universal indicator paper. Compare it with indicator dipped in tap water, household ammonia, and household vinegar.

b. Clean the nails with soap and water, rinse with alcohol and dry with paper towels. Be careful not to touch the nails with bare hands after rinsing.

c. Fill each of four petri dishes about half-full. Place tap water in one, leachate in another, household ammonia in the third, and vinegar in a fourth. Place one nail in each dish.

d. After a few days, when the liquid has evaporated, observe the nails. Record the observations. Have the nails changed in appearance?

e. Discuss results in relationship to landfill management. **Ask:** Why do we need to try to control the amount of liquid in a landfill? Under what conditions do metals leach? What other materials leach under the conditions found in a landfill?

2. How Leachate Affects Plants

To perform another experiment with the leachate sample, ask the students to bring to class an egg carton containing nine eggshell halves.

You will also need the following materials:

- 3 different types of soil (clay, loam, sand)
- approximately 20 small plants 1" to 2" high (radishes germinate quickly)
- soil testing kit
- student record sheets (included)

a. Discuss soil structure and compare soils with three different structure types — heavy (clay), medium (loam), and light (sand).

b. Have the students prepare three seed beds from each of the three soil types, using the eggshell halves as containers. (Have the students prick tiny drainage holes in the bottoms of the eggshell halves.)

c. Have the students sow several radish seeds in each shell half and keep them moist during germination. (Plastic wrap laid on top will hold moisture in the soil.)

d. When the radish plants are one or two inches high, water one bed of each soil type with distilled water (control group), one bed of each soil type with leachate drawn directly from the landfill model, and the other bed of each type with leachate that has been passed through a column of soil. (Discuss the movement and dilution of leachate, including how continued movement changes the degrees of dilution.) Use the same measured volume of liquid on each plant. (Be sure not to overwater.)

e. Have the students record the condition of the plants and after one hour, 24 hours and 48 hours. Observe for signs of obvious ill effects (or, as might be possible, temporarily beneficial effects for added nutrients in the leachate. Record the observations on the student sheet, *How Leachate Affects Plants*).

3. How Leachate Affects Living Things

Measure 1 ml of leachate in a container and add 99 ml of distilled water (to simulate the dilution of leachate due to normal movement through soil).

a. Place 10 to 20 living *Daphnia* in the container. (*Daphnia* are any of a variety of small

freshwater crustaceans of the genus *Daphnia*, some species of which are commonly used as food for aquarium fish.)

b. Record any change of activity or obvious death after 1 minute, 2 minutes, and 5 minutes.

CAUTION: MAKE SURE STUDENTS TAKE PROPER PRECAUTIONS SUCH AS WEARING PROTECTIVE CLOTHING, GLOVES AND GOGGLES BEFORE PARTICIPATING IN THE FOLLOWING SEGMENT OF THE

EXPERIMENT: Include hazardous wastes — household chemicals such as hazardous pesticides, nail polish remover, cleaning fluids, etc. — in your landfill model. Have leachate samples analyzed at a laboratory. How might this leachate affect groundwater? Should household hazardous wastes be landfilled in municipal solid waste landfills? If not, what should we do with them?

Continue testing plants watered with leachate samples that have passed through increasingly more soil.

Questions for the Class

Discuss the results of this lesson in terms of the following:

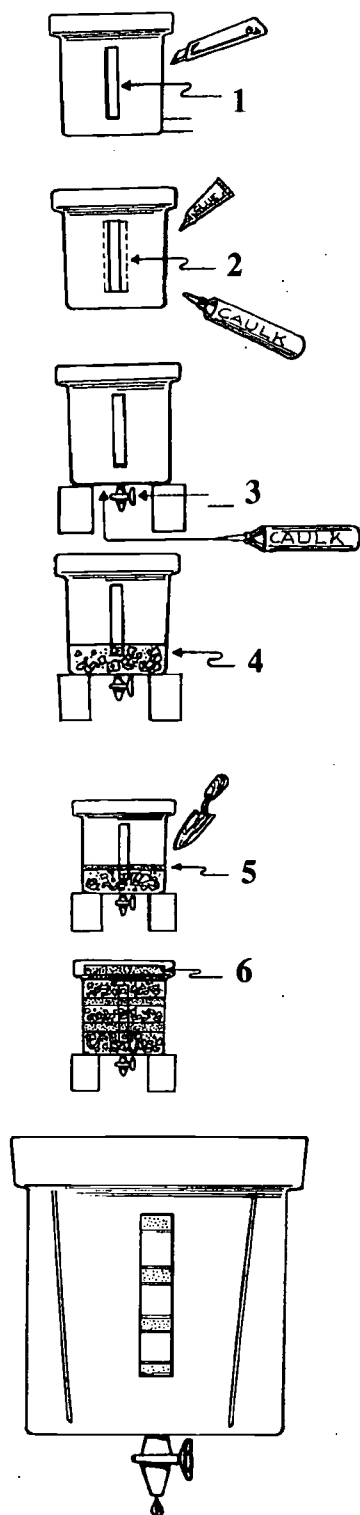
1. The need for monitoring streams, wells, and springs located below the elevation of landfill sites.
2. The importance of reporting unusual odors in drinking water and knowing to whom such information should be reported.

Just Do It

Hazardous wastes in your household trash are dangerous. Unfortunately there is no ready solution to household hazardous waste and in some cases, the municipal landfill is the best of several poor choices. If you are unsure about what to do with a household hazardous waste, call the South Carolina Department of Health and Environmental Control,
1 (800) SO-USE-IT.

Construction of a Sanitary Landfill Model

(Using a 30-gallon garbage container.)



1. Cut a 2" x 30" vertical strip from a 30-gallon (or larger) garbage container, leaving the container intact for at least 3 inches of the bottom.

2. Glue a 4" x 30" piece of Plexiglas to the inside of the container and over the cutout. This will allow you to view the contents of the model landfill. This window will show the strata of waste and soil. (The window may be marked in increments of inches to help with layering soil and waste.)

3. Before inserting a screw-in faucet on the side, or at the bottom of the elevated model, cover the back of the faucet (the opening inside the tub) with the screened wire. This will help keep waste material from flowing out with the leachate. Seal around the faucet with caulking compound.

Preparation of Waste

In a sanitary landfill, the accepted ratio of soil cover to waste is 1:12 (6" of soil: 72" of waste). In this model, 1" of soil cover will be used for 12" of waste. (If you use a smaller trash can, try to stick as close to this ratio as you can.)

4. Place one layer of waste in the landfill model.

5. Cover the first layer of waste with 1" to 2" of damp soil. Tightly pack the soil cover by pounding it firmly to simulate a real landfill situation.

6. Continue the layering and compacting until the landfill model is full. The final layer should be 4" of soil.

STUDENT WORK SHEET – How Leachate Affects Plants Experiment

Control Soil Samples	<u>Plant Condition After:</u>		
	1 hour	24 hours	48 hours
Soil Type #1 _____			
Soil Type #2 _____			
Soil Type #3 _____			

Chart 1

Pure Leachate on Soil Samples	<u>Plant Condition After:</u>		
	1 hour	24 hours	48 hours
Soil Type #1 _____			
Soil Type #2 _____			
Soil Type #3 _____			

Leachate through Soil on Soil Samples	<u>Plant Condition After:</u>		
	1 hour	24 hours	48 hours
Soil Type #1 _____			
Soil Type #2 _____			
Soil Type #3 _____			

STUDENT WORK SHEET

Control Soil Samples

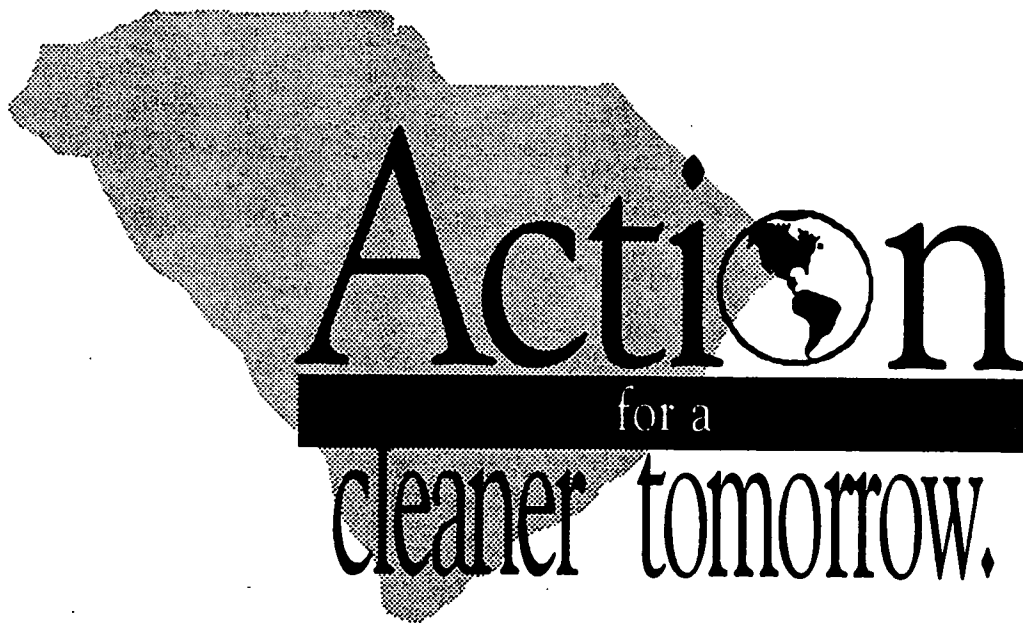
Soil Type #1	pH _____	P _____
	K _____	NO ₃ _____
Soil Type #2	pH _____	P _____
	K _____	NO ₃ _____
Soil Type #3	pH _____	P _____
	K _____	NO ₃ _____

Pure Leachate on Soil Samples

Soil Type #1	pH _____	P _____
	K _____	NO ₃ _____
Soil Type #2	pH _____	P _____
	K _____	NO ₃ _____
Soil Type #3	pH _____	P _____
	K _____	NO ₃ _____

Leachate through Soil on Soil Samples

Soil Type #1	pH _____	P _____
	K _____	NO ₃ _____
Soil Type #2	pH _____	P _____
	K _____	NO ₃ _____
Soil Type #3	pH _____	P _____
	K _____	NO ₃ _____



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South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Your Waste Is My Waste...

9.LA.5.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Environmental quality

Subjects: Music, Social Studies

Materials: "This Land is Your Land" sung by Woody Guthrie, a general folk song book

Teaching Time: One class period

Vocabulary: Waste reduction, broadside

Learning Objectives

Students will:

- create new words to old songs
- understand the folk music process
- hear how music can be used to promote environmentally sound actions by increasing public awareness of waste reduction and recycling issues.

Background

Broadside ballads first appeared in England not long after the invention of the printing press. Songs on subjects of current interest were printed on single sheets called a **broadside** and sold in the streets. The songs themselves were sung by street musicians as they hawked the broadsides. Most of the songs were about political issues, some current tragedy, or feat of heroism. The authors usually wrote the new words to old familiar melodies.

These songs fall into three broad types. The first are parodies, the song imitates the words of a traditional song, but the songwriter paraphrases them to fit the current situation. (Quite a few humorous songs also fall into this category.) The second kind of song is the pattern song. In these songs, a pattern is established in the first couple

of verses and the pattern can be applied to most any topic or situation. Blues and many play songs for children are pattern songs; *Mary Had a Little Lamb*, for example. The third type of broadside simply puts new lyrics to old familiar melodies. This makes the songs easily accessible to the average singer who doesn't need to learn a new tune. A strongly rhymed lyric functions to make the songs easier to learn and remember. The ideal is a "catchy" melody wedded to readable verses and an easily remembered chorus. Recent events stimulating examples of putting new lyrics (words) to old tunes were the "garbage barge" incident in New York and the Exxon oil tanker spill in Valdez, Alaska.

In many ways, the original street singers and the broadside ballad tradition were forerunners of our modern mass media system. Advertising "jingles" follow the same pattern of using familiar melodies, which today are likely to be a recent hit tune. The broadside sheet and the advertising jingle are concerned with persuading the listener to some action.

Questions for the Class

1. Where did broadsides come from?
2. Can you name two kinds of broadside songs?
3. How is advertising similar to a broadside song?
4. What two features make a song easy to learn and sing?

Learning Procedure

1. Explain to students that folk music has a long history of being used by people to comment on problems of current interest. One of the problems we have today is what to do about the growing



Kevin Costner and Barbara Streisand hosted an EarthDay Special. Olivia Newton-John was chosen goodwill ambassador for the United Nation's Environment Program, Sting publicized the destruction of our rain forests, and Robert Redford regularly speaks out on global warming and other "green" issues. These are just a few of the many celebrities who champion environmental causes.

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amount of waste being generated. Ask students to name specific problems (*such as pollution from hazardous wastes, plastic packaging and the endangerment to marine wildlife, where to put our garbage now that landfills are closing, etc.*)

2. Hand out the songsheets of *This Land Is Your Land*. Explain to students that Woody Guthrie, the author of *Roll On Columbia*, wrote this song during the depression, and that the original had many more verses than we know now. The melody he used is very close to the traditional song, *Oh Little Darling, Pal of Mine*.

3. Have the class sing this song. **Ask:** Is there a rhyming structure to this song? If so, what is it? Is it the same for all verses? For the chorus? (*Woody Guthrie was concerned more with the content of the songs than making good rhymes. The verses that remain alive in the oral tradition, however, are usually the ones with a strong rhyming component.*)

4. Have students break up into small groups of three to five persons. Assign each group a topic from the list below or let the groups pick their own topics:

- Landfills
- Recycling
- Littering
- Hazardous wastes and illegal dumping
- The growing volume of garbage
- Ocean pollution.

(*You may wish to use current newspaper or magazine articles as information sources for these and other environmental topics.*)

5. Tell students that each group is going to make up one or two new verses and/or a chorus to *This Land Is Your Land* on its topic. As an example, the handout includes some verses written by Steve Schuch of New Hampshire to celebrate the dedication of a recycling center. One way to get a group started is to have one person in the group start off with a line. The person to the left then makes up the second

line, etc. Suggest to each group that a particular rhyming style (lines 1 & 3 and/or 2 & 4; lines 1 & 2 and/or 3 & 4; etc.) be selected before working on the actual words.

6. After 10 to 20 minutes, reform the class and have the class as a whole sing the new "songs." Let one person from each group "line out" the new verses to the rest of the class. This means one person speaks the words of a single line just before the line is to be sung, and, if necessary, the speaker starts the line slightly before the last line has ended so as to preserve the timing of the song. (*Illustrate this with one or two verses of the original.*) Collect the new verses from each group and save for future uses or the Extension Activities.

Extension Activities

1. Have students take a recent pop hit and write new lyrics on the themes listed previously.

2. Write new words to a pattern type folk song. Some examples are: *Skip To My Lou*, *Worried Man Blues*, *Michael Row The Boat Ashore*, etc.

3. Explore the melodic and rhythm patterns in the two-song melodies. **Ask:** Is three-four (waltz) time easier to learn and sing than four-four (common) time?

Identify some of the key melodic and rhythmic phrases in the songs. Name other songs that have similar phrasing. Have upper level students translate the chord structure or transpose the songs into different keys.

4. Have students write out the lead sheets for the various versions. Collaborate with an art class to provide illustrations for the written music. Have these efforts published in the school newspaper.

5. Have students research and bring to class modern music that celebrates the environment or that points to environmental problems.

THIS LAND IS YOUR LAND
- Woody Guthrie

Chorus

F C
This land is your land, this land is my land,
G C
From California to the New York island.
F
From the redwood forests, to the gulf stream
C
waters.
G C
This land was made for you and me.

As I was walking that ribbon of highway,
I saw above me the endless sky way;
I saw below me that golden valley,
This land was made for you and me.

I've roamed and rambled, I've followed my
footsteps
To the sparkling sands, of her diamond deserts.
And all around me a voice was sounding,
This land was made for you and me.

As the sun came shining and I was strolling.
And the wheat fields waving and the dust,
clouds rolling,
As the fog was lifting a voice was calling,
This land is made for you and me.

THIS DUMP IS YOUR DUMP - Steve Schuch
Sung to the tune "This Land is Your Land"

Chorus

This dump is your dump, this dump is my dump
It's time to think how we manage our junk
From Washington's forests to her wetland waters.
Recycling can work for you and me.

As I was walking Washington's highways,
I saw beside me garbage in my way;
The cans and bottles and wrappers waving,
Recycling can work for you and me.

There was a time we thought it didn't matter
If dumps kept growing bigger and fatter
But we are growing a little wiser now.
Recycling can work for you and me.

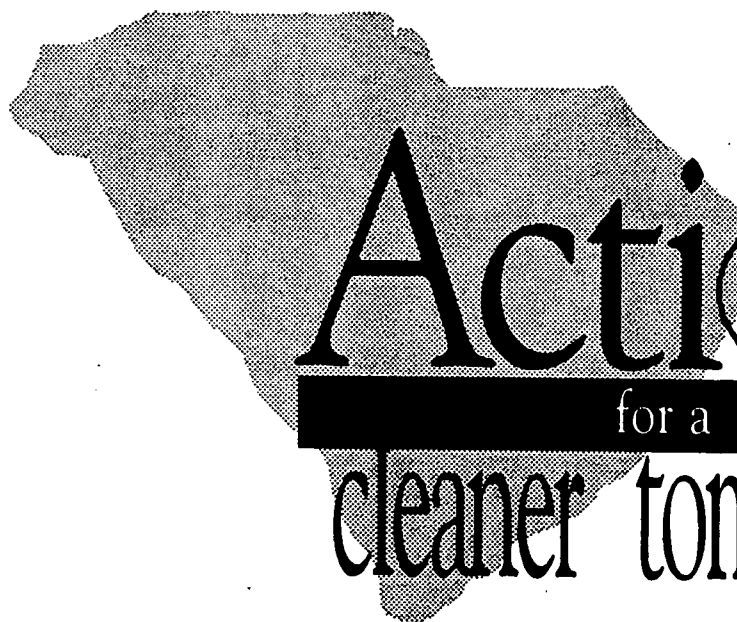
The sun came shining as I was strolling
Collecting cans to keep recycling rolling,
Selectmen dancing, everyone chanting.
Recycling can work for you and me.

No matter how far you pay to haul it
No matter how small you try to maul it,
The simple truth is that there is no away.
Recycling can work for you and me.

Just Do It

Put on a school environmental art and performing arts show. Have students write and perform environmental songs; write and recite environmental poetry; make "recycled" art sculptures, posters and displays. A class project may be to write an environmental musical or dramatic play and perform it as the highlight of the show.

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Deciding What To Do

9.LC.2.F

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

Focus: Examining the issues and the decision-making processes involved in siting waste disposal facilities

Subjects: Social Studies, Government, Environmental Science, Drama

Materials: See list of materials itemized below

Teaching Time: Several class periods, plus research over several weeks

Vocabulary: Solid Waste Disposal Act, RCRA, CERCLA, Superfund, NIMBY

Note: This lesson requires students to think about the many issues surrounding solid waste disposal. For this lesson to be effective, students should have a basic understanding of solid waste, landfills, incinerators, and solid waste regulations.

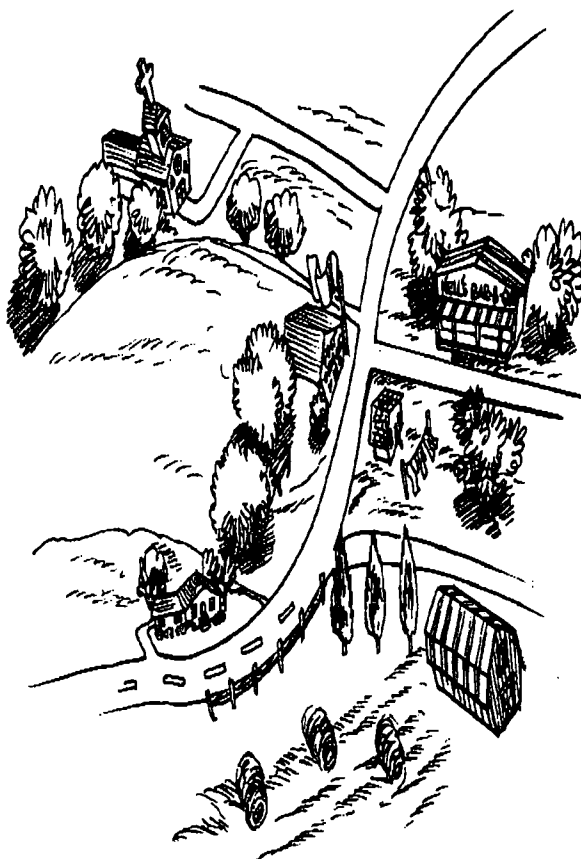
Management of solid waste and siting a garbage disposal facility are complex and controversial public decisions. In the decision-making process, a wide range of perspectives and values come into play.

The decision-making process used in managing solid waste is illustrative of the process used to decide other difficult public issues.

Learning Objective

Students will:


- see the complexity of managing solid waste
- realize the wide range of perspectives and values involved in making decisions about solid waste



- understand that there is no one “right” or “correct” answer to most of the serious problems facing our society
- learn an interdisciplinary decision-making process through role playing.

Materials

- Scenario and role descriptions (included)
- Sample hearing agenda (included)
- Newspaper and magazine articles from your local area on problems in the management of solid waste.



The environment is the leading cause of concern of Japanese citizens.
Source: 1993 Earth Journal

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To supplement these materials and to prepare students on the issues, have students collect information from newspapers, television news shows, and magazines related to siting landfills or incinerators. Review these as a class.

Background

For more information on Solid Waste, Landfills, and Incinerators, see the Resource section.

Regulations for environmental quality usually lag behind the factors that contribute to environmental problems. Prior to World War II, there were no environmental regulatory programs. States directed their efforts to land use not land quality. State and federal officials assumed the roles of advisors and persuaders. Only recently has government assumed a more active role.

The 1970 amendments to the federal **Solid Waste Disposal Act of 1965** were an important step toward addressing current issues in waste disposal methods. Emphasis began to shift from waste disposal to waste management and resource recovery.

The **Resource Conservation and Recovery Act (RCRA) of 1976** (amended in 1984) replaced the Solid Waste Disposal Act. This law regulated the disposal of solid waste and gave strict requirements for the construction of municipal solid waste landfills (Subtitle D) and incinerators. Subtitle D Landfill requirements went in effect October 1993.

The **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund")** reflected changing attitudes and increasing efforts to protect the quality of the land. Superfund provided federal funds to clean up major sites of pollution, such as abandoned dumping sites.

Learning Procedures

(Class Assignments Prior to Classroom Activity)

1. Have students research and report on the regulation of solid waste and related issues. Why do we need these regulations?

Divide the class into eight groups and explain to the students that each group is to research one of the following state and federal government agencies involved in the enforcement of solid waste legislation:

1. Environmental Protection Agency
2. Department of Energy
3. Army Corps of Engineers
4. Department of Labor
5. Department of Transportation
6. Department of Health and Human Services
7. Interstate Commerce Commission
8. South Carolina Department of Health and Environmental Control

Each group is to research, write, and present to the class a brief one or two page report that includes the name of the agency, its responsibilities, and the government acts for which the agency is responsible. This will serve as a review of how government must work together to provide answers to our complex solid waste situation.

(Classroom Activity)

2. The class will conduct a simulated refuse disposal siting/solid waste management hearing with class members taking the parts (*see descriptions*) of various participants' roles in the waste management decision-making process. The disposal facility under consideration includes options for an incinerator only, landfill(s) only, or both. For this exercise, students will be looking at the siting of a municipal solid waste facility. Other pertinent issues not explicitly on the hearing agenda, but which have direct or indirect bearing on the waste management problem as a whole, are:

- Waste prevention and reduction and what can be done to encourage it, especially in industry.
- Recycling and the role it should play in the overall waste management plan.
- Reducing industrial waste through the establishment of waste exchanges or treatment facilities.

These issues and others are part of the many questions facing communities and government agencies the world over as they grapple with the cumulative effects that result from our “throwaway” culture.

3. Distribute copies of the scenario and a role description to each participating class member in the simulation. For best results, use one role description for each group. Tell the students that the problem closely parallels the actual situation in a number of communities. The job of the class is to understand and discuss the solid waste problem and come up with solutions. The emphasis should be on possible alternative solutions and not just a single answer to the problem.

4. Choose a student to serve as County Commissioner/Hearing Examiner. Then choose other students to fill the roles (*see descriptions included.*) You may wish to assign some roles to more than one student. For example, have two Journalists; one from a large newspaper and one from a smaller weekly publication; or one from the daily paper and one from a magazine. If the class is large enough, let some of the roles be assigned to two or three students who will each study and research a particular aspect of their roles’ concerns about the counties disposal strategies. Not all the roles are necessary, but the “hearing” will work best if at least the first six or seven parts are included.

5. An alternative approach is to assign the more technical and science oriented roles, such as Scientist, Expert, Toxicologist, Incinerator Vendor, etc., to a Chemistry and/or Biology class, while giving the other roles to a Social Studies class. The final hearing could be held in two sessions, one for each class.

6. Explain to students that this simulation is not meant to represent any actual public hearing or governmental hearing process, but that many public bodies are required by law to solicit input and comment on complex projects that can affect human health and environmental quality.

7. Have students prepare to play their roles realistically and convincingly by having them contact their real counterparts in your county. Encourage students to add substance and appropriate detail to their roles. You’ll notice that in the roles given, various positions and opinions are expressed. People use different terminology to describe what they agree with versus what they oppose. For example, people that oppose an incinerator may call it an incinerator while those for it may call it a waste-to-energy facility. This is not to say that all incinerators are waste-to-energy facilities, but points to the fact that people’s opinion color their descriptions.

Also, this example is for the siting of a municipal solid waste facility, that is, a facility to take only household and business garbage, not hazardous waste. This does not mean, however, that people won’t mix issues and bring in their fears about dangerous wastes.

8. Hand out the sample hearing agenda or prepare a similar one of your own. Assign a specific date or dates for conducting the hearing. Encourage all the participants to come prepared with either questions or a brief presentation as indicated on the agenda.

When the hearing takes place, have that part of the class not playing specific roles serve as the County Council, both questioning the hearing participants and, in the end, reaching a decision about what to do with all that garbage.

Extension Activities

1. Invite recyclers, environmental activists, solid waste engineers, garbage haulers, reporters, county commissioners, etc. to your class to describe the role each plays in dealing with your county’s solid waste.

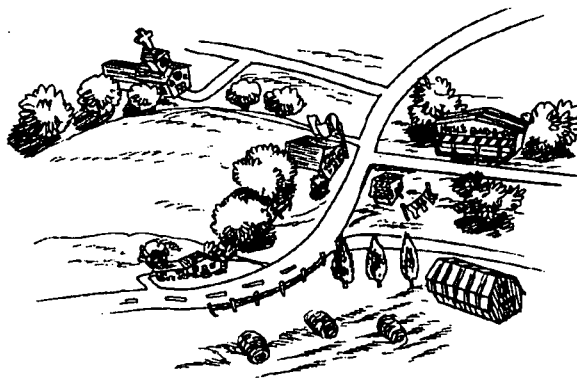
2. Invite these representatives to view your hearing and then to critique your arguments. How would they have handled their role in the hearing?

3. Share with the class the acronyms in the Garbage Dictionary. Have them think of others.

THE SCENARIO

County population is growing rapidly.

The volume of solid waste produced in the county is growing even more quickly. Federal and state regulations have outlawed open dumping, so all the old dumps have been closed. New U.S. Environmental Protection Agency guidelines for RCRA Subtitle D approved landfills are strict.



In building a new landfill, Subtitle D regulations are not an option, they are the law.

To protect human health and the environment, Subtitle D landfills must have safeguards built into them, but this makes it very expensive to construct. In addition, a Subtitle D landfill must be monitored throughout its use and for many years after.

Incinerators and waste-to-energy facilities are controversial. A brief federal moratorium on these facilities put them in the spotlight. Federal regulations on emissions are designed to safeguard the environment. These are strict and construction is expensive.

People have been attracted to living in the county because of its beautiful semi-rural character and thus are very sensitive about environmental degradation or property devaluation that may possibly result from a landfill or large-volume incinerator being built nearby.

The county public works department, which has responsibility for proper disposal of all municipal waste generated within the county, is increasingly concerned about the growing amount of waste and is considering both an incinerator and/or a new landfill. The existing landfill is filling up fast and, given the long lead time needed to site and build a replacement, a decision about what to do with the county's waste must be made soon.

ROLES



ACTIVIST

You oppose any new waste facilities. You feel strongly that more recycling could be done in the county. You think the county should require home source separation of recyclable materials such as aluminum, glass, plastic, and newspapers. Private or public garbage haulers should be required to provide separate pickup for recyclables. You'd like the county to institute a county-wide, per-can garbage collection fee schedule that allows as little as one pickup a month. You want the county to fund public education programs in recycling; programs both for citizens' groups and schools.

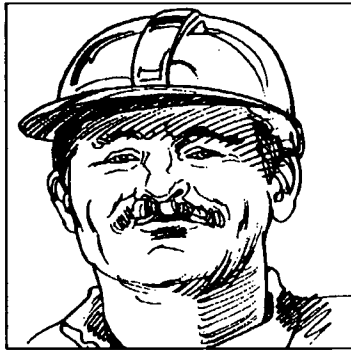
You oppose the construction of an incineration plant. You are concerned about the effects of incinerator emissions on air quality. You understand that an incinerator will require huge amounts of refuse to operate efficiently and thus may discourage recycling efforts, while at the same time presenting problems in disposing of the ash generated. You believe that a landfill could cause considerable environmental damage to the land, air, and water.



COMMERCIAL RECYCLER

You became involved in recycling a long time before concerns about environmental degradation were first voiced. Profits have never been large and the markets for recyclables have never been particularly stable or reliable. Nevertheless, the satisfaction of knowing that your job is part of the solution and not part of the problem has always made the hard work and long hours necessary to survive more than worth it. After 20 years, you have carved out a secure market for your business and you are looking forward to relaxing a little, while letting the younger generation carry on the day-to-day work.

You are worried that an incinerator will cut the bottom out of the recycling market. Although you would like to see the city institute mandatory recycling and source separation, you recognize that your own business is probably too small to compete with the large waste management firms that the city would most likely end up contracting with for such a mandatory program. You are gratified that at last recycling is becoming a "big business" and thus respectable, but you are angry and a little bit frightened that you and your hard-earned business will get lost in the shuffle.



GARBAGE HAULER

You own a garbage collection company. Your company is licensed by the state and franchised by the county. Your prime concerns are providing good service to a rapidly growing number of customers and keeping costs down. You are also concerned about county and state regulations of your business. In recent years, more of the task of running your business has been taken up with government forms and "red tape." You are concerned about the prospect of the county telling you how to set your collection fees, how the garbage itself must be picked up, and where you have to take it once it has been collected.



SPOKESPERSON, HOMEOWNERS' GROUP

You are worried that the county/city may be planning to build a landfill or an incinerator near your home. You are worried about the roadway litter that may result. You are also concerned about the increase in the rat, crow, sea gull, and wild dog population that a landfill may bring. You are also worried that household hazardous wastes dumped into the landfill will generate toxic leachate that could contaminate your drinking water. You are angry when you think that a landfill or incinerator may decrease the value of the house and land you've worked so hard to own.

As the co-founder of a civic organization against Incinerators/Landfills you have been asked by the organization to present the group's concerns at the upcoming hearing. You realize, however, that it is not enough to protest a specific site, but that appealing and feasible alternatives must be presented. For this reason your organization has come out in favor of increased recycling.



COUNTY PUBLIC WORKS ENGINEER

Your county department has responsibility for disposing of all waste generated within the county.

You also have responsibility for meeting federal and state regulations governing the disposal of waste. Part of your job is to design and build waste facilities such as landfills and incinerators. At the same time, you are required to ensure that these disposal facilities do not create hazards for the environment or human health. A great deal of your energy goes into selecting and evaluating possible disposal sites and advising county commissioners/council members on technical aspects of solid waste management. You are becoming alarmed at the rate of growth of the county's volume of solid waste and, probably most acutely, realize the enormity of the county's solid waste problem. You ask yourself: "Where is all this stuff going to go?"

Lately, however, much more of your time has been taken up with public relations, dealing with the concerns and sometimes anger of citizens who question or challenge county solid waste policy or decisions. You believe that citizens need to be better informed about some of the scientific and technical issues that are part of deciding what's the best option. You are especially concerned that the press is playing up some of the more sensational but remote dangers associated with incinerators and landfills. It seems that no matter how well you document the safety of a waste-to-energy incinerator or a landfill site, the papers always play up the negative aspects.



COUNTY COMMISSIONER/COUNCIL MEMBERS

Your job is to make the final decision about how to deal with the county's growing volume of solid waste, while taking into account the needs and interests of a broad range of county citizens and businesses. You have to understand both the technical information provided you by the public works director and the anxiety of homeowners who feel threatened by the possibility of a landfill or incinerator in their area. You try to be pragmatic and fair. You also want to get re-elected to office.

Your role in the hearing is to conduct a landfill siting/solid waste management discussion by calling on and questioning the citizens who have a position or an opinion to express. It is also your responsibility to seek the input of other county commissioners/council members and interested citizens. It is your responsibility to conduct an orderly and productive meeting. This means that each participant should be treated equally and that all viewpoints are given a fair hearing.



COUNTY CITIZEN

You lead a busy life. You like the convenience that some packaged and processed foods give you, though you are sometimes bothered by the amount of packaging left over.

You know your county is growing rapidly but have been more concerned about other consequences of growth such as crime and crowded highways than you have been about an increase in garbage. Frankly, you'd like to throw your trash in the garbage can and forget about it, even though you know in the long run that your children or grandchildren may end up paying for it with a less healthy environment.

You're paying the garbage hauler and the county taxes to take care of trash for you. You don't feel you have enough time in your day to fool around with the trash, separating it for recycling. And you don't want any thing to do with higher taxes.



JOURNALIST

Time and time again you've been assured by elected officials that the city has its garbage problem under control, only to learn later, after careful digging, that the plans made have proved to be inadequate for the mounting garbage generated daily through expanded growth. When you ask about safeguards for environmental and human health, the engineers and planners present seemingly endless numbers and graphs all purporting to establish the safety of the sites being proposed for the disposal facility.

Your job is to ask hard questions, understand the important issues, and report accurately the decision-making process.



INCINERATOR PLANT VENDOR

You believe that incineration is the best solid waste management method available. As an engineer with many years of experience in waste management and chemical processes, you know that the technology for safe incineration is already available and you don't understand why some citizens are fearful and unwilling to trust your professional judgment.

If asked, you would have no qualms about having an incinerator site next to your property.

You want your company to be selected for this county's contract. Your boss has promised you an especially attractive bonus if you can "land" this one. You also know that waste incinerators, under the right conditions, are good opportunities for investors.



REGULATORY AGENCY OFFICIAL

You have been assigned by your agency to carry out state law as mandated by the State Legislature. Your responsibility is to write about enforcing regulations that will protect public health and the environment yet still provide practical and economically feasible waste management facilities.

You are sensitive to the public's view of you, yet you know that there is no perfect set of regulations that will please all the parties. From your experience as a field inspector, you know that strict enforcement of the law doesn't always lead to the desired result of a safer environment. You are sometimes as frustrated as the public by the legal requirements built into the regulations as safeguards against unjust government actions, but which are all too often exploited by a few "bad eggs" at the expense of the many.

It is sometimes hard to remember that most individuals and businesses are honest and want to comply with the law, especially as it relates to the environment.

You have been asked to attend this hearing to explain the current state and federal regulations and how they affect the county's proposal for siting a disposal facility. You expect to be questioned closely by both citizen and industry groups.



SCIENTIST EXPERT

You are a professor of geology at a nearby university specializing in hydrology, the study of water movement in the earth. Your research has focused on groundwater flow and the scientific study of the problems associated with contamination from human activities.

Your publications have appeared in numerous journals and your scholarly expertise has been acknowledged by many professional organizations throughout the world. As your reputation as an expert has grown, you have been called on to speak at a growing number of public hearings and workshops throughout the state, including testimony at legal trials on the safety of various disposal options with respect to potential and actual groundwater contamination. You know as a scientist that there is no such thing as certainty, especially in a field like geology where most events are measured in millions of years, and actual experimental verification is possible only on a limited basis. Nevertheless you find yourself being asked to give “yes” or “no” answers to questions that scientific and technical knowledge can never provide.

The county commissioner has asked you (for a fee) to examine the county’s plans for disposal and to provide a brief report discussing the impacts that each option might have on the water supply now and in the future. At present the data available and current scientific models can only suggest in a most sketchy fashion what these impacts might be. You are worried that, because of this, each faction will seize upon those parts of your presentation that most closely support its position and then point to you as proof of the “truth” of its claims.



COUNTY ATTORNEY

The district attorney’s office reviews all the county plans to ensure that the county does not violate any of the many governmental regulations that inevitably cover any large-scale plan.

Projects with the potential for environmental harm and/or human health effects are especially complex, involving as they do both technical and political issues. You have been assigned the job of monitoring the legal aspects of the county’s waste management plans.

A top-notch lawyer, you welcome this assignment as the first step in your career as a public official. You have political ambitions, and you know how crucial it is to perform well on this assignment.

Your boss, the district attorney, is particularly concerned about the threat of lawsuits and other legal actions from various special interest groups, such as nearby homeowners, industry organizations, and environmental activists.



PRIVATE CONSULTANT

The county hired the firm you work for to study the various options for a garbage disposal facility. You have been part of the team that carried out the necessary research and your particular expertise is in the area of stack emissions in incinerators and the safeguards of the new Subtitle D landfill design.

Your supervisor is out of town this week and you have been tapped to represent the firm if any questions arise concerning the recommendations that were made to the county as part of your firm's final report.

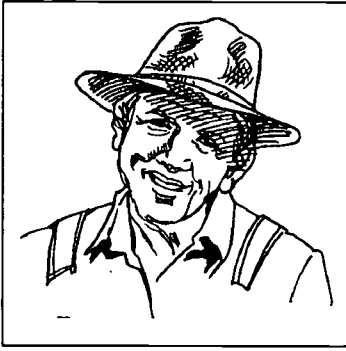
Since a landfill and/or incinerator were included as part of the recommendation, you expect to be sharply questioned on these aspects of the overall strategy your company proposed.



TOXICOLOGIST

You work at a federal government laboratory studying the effects of chemicals on mice and rats. Most of your research is directed toward determining whether certain chemicals can cause cancer in humans and animals. The main research tool for doing this is to expose special strains of rats and mice to substances and observe whether, or at what dosages, tumors develop. You know that many people are doubtful about relating results from mice to humans. Skeptics point out that experimental animals are exposed to high doses of substances at levels not commonly found in a normal living environment. You, however, know that to extrapolate to the low dose exposures that are typical of human environments, the 50 to 100 rats and mice must ingest enough toxin to produce a statistically significant number of cancers. Estimates of cancer-causing potency are based on the extrapolation of the experimental animal results to low doses.

Several environmental organizations have expressed concern about production of dioxins by the incinerator, either as smokestack emissions in the air or as part of the fly ash that must be disposed. Dioxins are a class of chlorinated organic compounds produced as byproducts in the production of herbicides and other products. At least one dioxin, TCDD, is the most potent carcinogen known in mice and rats. The evidence for its cancer production in humans is not, however, established, and scientists disagree as to what exposure levels are safe.



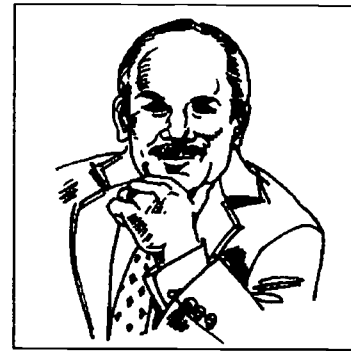
FARMER/AGRICULTURE REPRESENTATIVE

Your family has roots in the area that stretch back to the early pioneer days more than a hundred years ago. You have watched the county seat grow from a small town to a medium-sized city.

You are concerned about the rapid growth and its effects on prime agricultural land. In your view, building an incinerator or new landfill will encourage more growth and you know that your family farm may ultimately be threatened by this growth.

Taxes continue to increase and you have farmer colleagues who have been forced to sell their acreage due, in part, to rising property taxes. You feel strongly about your stewardship of the land and are worried that your family's longtime ties to the land may be broken.

When it comes to new people and waste disposal, you say "Not in my backyard."



REAL ESTATE DEVELOPER

You believe that progress must necessarily include some environmental disruption, but that the economic growth for the area far outweighs the short-term pollution of a "few" streams or the conversion of some prime agricultural land for suburban housing and shopping centers.

If most environmentalists had their way, the county would soon stagnate from the many regulations and restrictions that stifle growth.

You are convinced that the expansion now under way must not be interrupted and that desirable "high tech" industries can be attracted to the area only if they can be assured that there are adequate waste disposal facilities.

You believe that growth is inevitable and that, even if there are some minor problems now, scientists and engineers will come up with the necessary technology in the future to solve them. Sure, in the past, some mistakes were made, but there are plenty of safeguards built into the law now and, besides, it's always been necessary to "break a few eggs to make an omelet." You believe that an incinerator, especially a waste-to-energy incinerator designed to produce energy while it burns trash, is necessary for the continued economic health of the county.

You think that all the people who oppose progress have the NIMBY (Not in my backyard) Syndrome and should wake-up.



**CHAMBER OF COMMERCE
REPRESENTATIVE/LOCAL
BUSINESSPERSON**

You have been a member of the local business community for 20 years. Your business has been slowly growing after a struggle to make ends meet for the first 10 years.

However, the recent recession has caused you great concern: will you be able to meet the costs of college education for your two teen-aged children?

A waste-to-energy incinerator would bring cheaper electrical power rates and build an economic base in the county. Recycling efforts could bring in a few jobs, but larger companies outside the area are already prepared to initiate large-scale recycling efforts. A new landfill might cause a reduction in business opportunities, tourism, and residential growth. However, when it comes to where a facility should be located, you say anywhere except my side of town.

**PUBLIC HEARING ON PROPOSED
MUNICIPAL REFUSE DISPOSAL
FACILITIES – THE AGENDA**

**I. Opening Statement - County
Commissioner**

**II. County Proposals - Public
Works Engineer**

**A. Combination Incinerator and
Sanitary Landfill**

**B. Waste Reduction/Recycling
with Smaller Landfill and
Incinerator**

**C. Long Distance Hauling to
Another Part of the State**

D. Question Period

III. Expert Reports

IV. Citizen Testimony

**A. Citizen Environmental
Group**

B. Organizations

V. Industry/Business Testimony

**VI. Final Summarization and
Questions**

**VII. Conclusion and Vote -
Commission Members**

**VIII. Report of Proceedings by
the Journalists**

Garbage Dictionary

excerpts from *Garbage* magazine

NIMBY – This acronym for Not In My Backyard sums up some peoples' reaction when plans for the new landfill or incinerator are unveiled.

GUMBY – Gotta Use Many Backyards. The divide-and-conquer methods of siting hazardous-waste facilities and the like: You've got six sites, and you only need to use one, you try to get people to fight it out. The town offering the weakest opposition gets the facility.

YIMBY (FAP) – Yes In My Backyard (For A Price). A new siting tactic: Waste-handling firms pay fat inducements, including road improvements, free disposal, and a piece of the dumping fee (which can total in the millions of dollars), to any community willing to "host" a large regional landfill or incinerator.

NIMTOF – Not In My Term Of Office. A waste-industry tag for politicians who buckle under to community opposition, leaving their successors to deal with the problem.

NIMIC – Not In My Insurance Company. When a community rises up to fight a waste site, they're branded hysterical housewives, but when an insurance executive refuses to underwrite a pollution liability policy for the same site, for the same reasons, he's credited with sharp business acumen.

NOPE – Not On Planet Earth. When the NIMBY syndrome gets them down, this term is muttered by waste handlers convinced that "NIMBY-ites" don't want disposal facilities sited anywhere.

PICESP – Put It In Corporate Executives' Swimming Pools. In fevered moments, this term is used by radicals that think waste management executives should just keep it.

NIMFY – Not In My Front Yard. If "NIMBY-ism" is taken to extreme, and there are no more garbage pickups because no one will accept new recycling facilities, landfills, or waste-to-energy plants, NIMFY is what people will be crying as we watch our waste pile up.

The Road to Energy Recovery

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Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

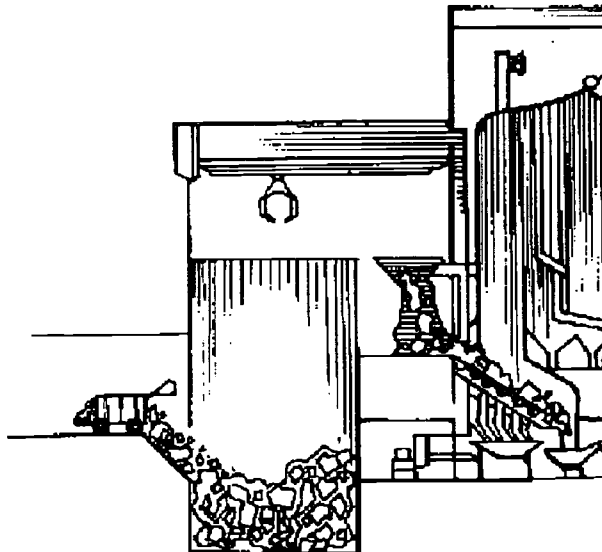
Focus: Waste management, decision making

Subjects: Government, Environmental Science, Debate

Materials: *Waste-to-Energy Facility* transparency, *The Road to Energy Recovery* handout sheet (one per student), optional: DHEC video "Trashumentary"

Teaching Time: Two or three class periods plus research

Vocabulary: Short-term impact, long-term impact, waste reduction, waste-to-energy, NIMBY syndrome



Learning Objectives

Students will:

- list some of the considerations needed to site a waste disposal facility
- explain the necessity for long-range waste management planning
- examine environmental and social problems associated with waste management.

In this lesson, students research the pros and cons of incineration as a waste management alternative and present their positions in a simulated town meeting.

Background

For more information about incineration and waste-to-energy facilities, see the Resource section on Incineration. Also see the excerpts from two articles from *Waste Age* magazine, November 1992. These are included for background and student reading.

Nearly 2,500 years ago, the city of Athens, Greece reached a crisis point. The threat was not invasion,

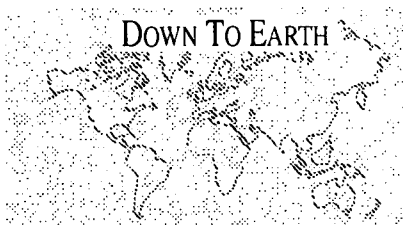
political unrest, or a failing economy; the city was simply choking on its own trash. In response, the government opened the first recorded municipal landfill and decreed that wastes were to be carried more than one mile beyond the city gates.

Today the story is much the same, except that the scale has expanded immensely.

South Carolina Waste Management

In South Carolina, about 8 million tons of solid waste are generated every year. This waste represents commercial (industrial wastes), residential, and institutional wastes. Most of this waste is carried away and buried in the state's landfills – 39 municipal solid waste, 105 construction and demolition debris, and 60 industrial waste.

Until recently, most counties owned and operated a landfill that was used for the disposal of municipal solid waste. South Carolina is experiencing a dramatic decrease in the number of landfills as a



In Denmark, 70 percent of domestic waste is burned in municipal facilities. In France, 35 percent of municipal solid waste is burned, 23 percent of this at waste-to-energy plants.

Source: *Waste Age*, November 1992

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regional approach is being explored. Of the state's 39 municipal solid waste landfills, only eight meet new federal standards. With new federal Subtitle D regulations on landfills, many South Carolina landfills will close, while others are reaching their capacity.

As landfill space becomes scarcer and more expensive, and as the environmental problems caused by past practices become more evident, communities must look for new solutions to the problems of increased economic and environmental waste disposal costs. Some experts believe that landfills have become a valuable resource that must be conserved and should be used only for waste that cannot be treated any other way.

No single approach or method will solve South Carolina's growing solid waste problems. On the contrary, the key to an effective waste management system lies in developing an integrated program.

The four major components of an integrated waste management system include: waste reduction, recycling, landfilling, and incineration in waste-to-energy (energy recovery) facilities.

According to S.C. DHEC statistics, in 1995, 16 percent of South Carolina's solid waste is recycled, 60 percent was buried in landfills, 10 percent was composted, 10 percent was chipped but not composted, and 5 percent of was incinerated. All of this waste was burned in **waste-to-energy** facilities. *(Energy recovery facilities convert solid waste to steam heat and/or electricity through high temperature, controlled combustion.)*

In contrast to landfilling, incinerating, and recycling, which are all designed to deal with solid waste *after* it is produced, probably the most important component – **waste reduction** – aims at changing manufacturing and social practices to decrease the amount of solid waste created.

The South Carolina Solid Waste Policy and Management Act of 1991 mandates South Carolina's communities increase the amount of

solid waste they recycle and decrease the amount of solid waste they landfill. The Act stipulates that by 1997, communities must reduce at least 30 percent of their solid waste, 25 percent of that reduction must be through recycling efforts. According to the South Carolina Solid Waste Management Plan:

"Incineration is the most effective volume reduction method (of waste reduction), as it can result in 70 to 90 percent reduction, by volume by weight. There are two solid waste combustors in the State. Charleston County has a 20-year agreement with Foster Wheeler to own and operate the boiler in Charleston County. It receives approximately 225,000 tons of solid waste annually. The facility, while termed a boiler, is more appropriately referred to as a waste-to-energy operation. The steam produced at the site is sold to the Charleston Naval Shipyard and electricity generated from the steam on site is sold to Carolina Power & Light.

"Chambers Medical Technologies of South Carolina, Inc., owns and operates an incinerator in Hampton County. It receives and incinerates approximately 68,000 tons of solid waste annually. This includes most of the solid wastes generated in Bamberg, Colleton, and Hampton counties and other special wastes generated by industries located outside this area. Attached to the incinerator is a heat recovery system. From this system, (Chambers) produces steam that is sold to Westinghouse. Therefore, this facility is a waste-to-energy operation as well ...

"Nearly 75 percent of the municipal solid waste stream is combustible. Therefore, combustion provides the greatest degree of volume reduction, 70 to 90 percent. A county/region with a large concentrated population should consider a waste-to-energy, or combustion system as part of the volume reduction efforts of its integrated solid waste program. However, combustion does not offer the most cost-effective solution for each county/region."

Waste-to-Energy Benefits

Waste-to-energy incineration has a number of benefits in addition to saving valuable landfill space. It conserves energy and can conserve resources (metals, plastics, paper, and glass) if these materials are separated from the solid waste before it is burned. Waste-to-energy facilities can also generate revenue for communities: In addition to “tipping” or disposal fees, revenues from selling the energy generated at waste-to-energy facilities can reduce operation and maintenance costs. However, waste-to-energy incineration has some drawbacks.

First, energy recovery facilities are expensive to build. Construction costs can be as high as \$100 million for each 1,000 tons of capacity. Second, as part of the combustion process, toxic materials including dioxin (a known carcinogen), acid gases, and carbon monoxide are emitted. In addition, after the burning process is complete, a significant amount of residual ash remains. This ash usually contains heavy metals such as lead and cadmium and other toxic materials such as arsenic, chlorine, chloroform, and benzene. This ash must be removed and disposed in specially permitted ash monofills (landfills).

As communities wrestle with waste management options, citizens must become involved in the decision-making process. They must obtain factual information regarding the pros and cons of each waste management strategy and use this information to make informed decisions.

The decisions communities make today will have both **short-term** (immediate) and **long-term** (future) impacts. Often, an “ideal” short-term solution can have disastrous long-term impacts.

Learning Procedure

1. Review with the class the Background information on Energy Recovery and Incineration included with this lesson as well as that found in the Resource section. Discuss the terms “short-term impact” and “long-term impact.” Ask students to think of examples of short and long-term impacts associated with actions or events such as spraying DDT on crops to kill insects, building a highway in the middle of a nature preserve, or filling in swamps to build homes.

2. Discuss some of the important environmental factors that should be considered when building a new facility such as a school or a highway. Examples include:

- How will it affect the wildlife?
- How will it affect the plant life?
- How will it affect the people in the area?
- How will it change the area?

3. Briefly review the four solid waste management strategies used in South Carolina (*landfilling, waste-to-energy incineration, recycling, and waste reduction*). Explain that this activity will focus on waste-to-energy incineration as a solid waste management strategy.

4. Project the *Waste-to-Energy Facility* transparency and review the basic steps of the facility’s operation.

5. Distribute a *Road to Energy Recovery* to each student and review the major points of the sheet. Set the following stage for the activity: “A waste-to-energy facility has been suggested for your hometown, but there will be no approval until a variety of environmental factors are investigated thoroughly. The panel selected by the Mayor will then approve or disapprove the facility.”

6. Divide the class into three equal-sized Research and Presentation Teams as follows:

Team A: In favor of building the waste-to-energy facility (be sure to address the Not In My Back Yard [NIMBY] syndrome)

Team B: Opposed to building the waste-to-energy facility (be sure to address the Not In My Back Yard [NIMBY] syndrome)

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Team C: Company willing to build the facility (be sure to address the Not In My Back Yard [NIMBY] syndrome)

7. Review the following major considerations with each team:

In Favor: Lowers taxes, conserves landfill space, better than another landfill, provides cheap source of electricity.

Opposed: Lowers property value, increases truck traffic and litter, air pollution from stack emissions may harm people, technology not proven, may cause noise pollution from facility and trucks.

Company: Positive contribution to community by reducing waste volume, electricity will be produced and many jobs created, pollution controlled by devices that meet all federal standards for air emissions, facility will have monitoring system and will not create environmental problems.

8. Direct each team to investigate its position and be prepared to present arguments to the selected panel. Remind students to consider both short-term and long-term impacts. Students can conduct research in the library and/or collect information from private and governmental agencies. Research time and presentation format are at the discretion of the teacher. You may encourage the use of charts and graphs to support points and encourage students to site sources for their data.

You may wish to select a Mayor and panel from another class or other teachers. An odd-numbered panel is suggested in order to ensure a majority decision.

9. After research has been completed, hold a simulated Town Meeting. Have students from each team make their presentations and discuss the issues. Then have panel members vote on the proposed waste-to-energy facility and explain the reasons for their decision.

10. Conclude the activity with a discussion of the importance of community involvement in the decision-making process.

Questions for the Class

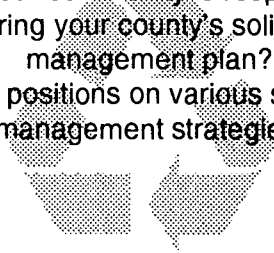
1. List at least one consideration identified by *each of the three teams* regarding the site location of the waste-to-energy facility.
2. Explain why long-range planning of waste management is important.
3. Name two environmental and two social issues identified in the simulation activity.

Extension Activities

1. Plan a class trip to a local Town Meeting.
2. Invite local officials to speak to the class about local waste management practices. (Contact your county waste management officer or the local Department of Health and Environmental Control office. For the name and number of your local DHEC office call 1-800-SO-USE IT.)
3. Invite a certified Solid Waste Specialist to visit your classroom. Contact your local Clemson Extension Office for more information.
4. Invite a foreign exchange student to visit your class and present his or her country's method/practice of solid waste disposal.

Just Do It

Who in your community is responsible for preparing your county's solid waste management plan?
Ask their positions on various solid waste management strategies.



The Road to Energy Recovery

Hometown is a small but growing community of 9,000 people in a rural setting. The people are proud of their community. It is near *Metropolis*, a very large city that has developed “overnight.”

People living in *Hometown* enjoy the variety of wildlife; many are avid sports and outdoor enthusiasts. In addition, parts of the area are protected due to the listing of one species of the wildlife population on the state’s endangered species list.

The people enjoy living in *Hometown* because of its pleasant, year-round climate and the fresh air. Soils range from a sandy mixture near Big Fish Lake to a more substantial soil in the dense woodlands, with just a little clay in the northern extremes of the town. Rainfall is slightly above average which tends to keep the lake and other bodies of water clean and clear.

The majority of the working people in *Hometown* drive 20 miles into *Metropolis* each day on a major roadway which also connects *Metropolis* with *Big City*, 75 miles to the north. This creates a traffic build-up in the morning and in the evening. Otherwise, the route is not heavily traveled.

The Mayor of *Hometown* and his Town Council have noticed the growth of *Metropolis* and have been studying the effects it will have on their town. In particular, they are concerned about the increase in garbage generated by population growth and by the emergence of “convenience consumerism.”

In addition, they are troubled by the decreased capacity of the existing landfill. They have discussed plans by *Metropolis* to place a waste-to-energy, (energy recovery) facility (incinerator) in *Hometown* which would benefit both *Metropolis* and *Hometown*.

However, no decision will be made until the people in *Hometown* have a chance to discuss it with the Mayor. For this purpose, a Town Meeting will be held. Within this forum, the Mayor and a selected panel will hear the different viewpoints of the citizens. They will then decide, by vote, whether or not to proceed with the project.

The Mayor has requested each group presenting a position to address the following issues:

1. The possible impacts on water quality, air quality, noise, and traffic in the area.
2. The proposed facility’s economic impact on *Hometown*.
3. The costs to the environment and the benefits as they relate to *Hometown* in the short-term (immediate) or in the long-term (future).
4. Waste management alternatives to building a waste-to-energy facility.

(Note: This information has been excerpted from two articles that appeared in the November 1992 issue of Waste Age, and students and teachers are encouraged to obtain a copy of this issue of Waste Age and read the complete articles.)

The predictions on the future of Waste-To-Energy facilities' growth included in these articles were made before the U.S. EPA instituted a moratorium on incinerators, capping the volume of waste each incinerator can accept and burn and effectively stopping all new incineration permitting and construction for the near term.

Regardless of the status of the federal moratorium, which is in debate, in South Carolina, no community can gain a permit for an incinerator to be built until its local solid waste management plan is approved and in place.)

Energy From Municipal Waste: Picking Up Where Recycling Leaves Off

Today an equivalent of 1.3 million homes are powered from energy that is produced from the combustion of more than 31 million tons of municipal solid waste (MSW) annually. That figure represents an increase of about 18 percent since 1990.

Accompanying this rise is a growing appreciation for the role that combustion [incineration] plays in power production or, as some put it, in recycling energy. Describing Camden County, N.J.'s, new waste-to-energy (WTE) [incineration] facility, Executive Director John Purves explains: "Although our county recycling program recovered 350,000 tons per year of glass, metal, yard waste, and other material, we still had 450,000 tons of trash left over. With our resource recovery facility [incinerator] in operation, we are now recycling the energy out of 330,000 additional tons of waste — a dramatic increase in our recycling percentages."

U.S. EPA's hierarchy for waste management alternatives also recognizes the importance of waste-to-energy. It does this by emphasizing the reduction and recycling of materials, then the recovery of energy [through incineration], before disposal in landfills.

How is energy recovered from municipal solid waste? What is it worth? How much is produced?

Energy from municipal solid waste

Energy from municipal solid waste is captured through the generation of steam in a boiler which, in

turn, can be put to beneficial use in numerous applications. For example, power in the form of steam or hot water can be used for space heating in buildings, as process heat for industrial operations, or for use in municipal district heating/cooling systems. Steam can also be used to run a turbine and generate electricity. The type of power that is ultimately produced at a waste-to-energy plant depends upon the availability of markets. Under federal law, electric utilities are required to purchase energy from qualifying facilities like waste-to-energy and therefore provide a guaranteed market. Industrial markets for steam are often more economically attractive, depending upon the internal cost of the steam product, but are also often more difficult to locate. Regardless of the ultimate market, the price of power from waste-to-energy plants is subject to negotiation. Successful negotiation of a power contract is critical to the economic viability of most projects. This is because the revenues from energy sales help to offset capital, operations, and maintenance costs associated with the plant.

The power generation capability of a waste-to-energy facility is typically based on the overall heat release rate of the municipal solid waste burned (e.g., million Btu/hour), not the mass throughput of the plant (e.g., tons per day). As the municipal solid waste heating value (e.g., Btu/lb) changes due to changes in waste stream composition, the mass throughput of the plant will go up or down accordingly. For example, a waste-to-energy plant designed to process municipal solid waste with an average heating value of 5,000 Btu/lb would require a throughput reduction to compensate for an increase in the municipal solid waste heating value due to the removal of glass, metals, high-moisture yard waste, and other materials for recycling (See

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the box for the energy value of various fuels). In spite of this variability in waste-to-energy fuel, the process of generating power is essentially the same as other steam plant processes. This process is often referred to as the steam generating system.

Steam generating system

The steam generating system at modern waste-to-energy plants normally consists of four sections: the waterwall furnace, superheater, boiler (evaporator), and economizer. [See illustration.]

The furnace is where the municipal solid waste burns at combustion temperatures in the range of 1,800°F to more than 2,000°F. This ensures complete conversion of the organic material in the municipal solid waste to simple gases. For most mass-burn and refuse-derived fuel (RDF) facilities, the walls of the furnace are surrounded by water-filled tubes called waterwalls. These tubes, through which water is circulated from the steam drum, absorb heat from the furnace.

In the boiler, the water is evaporated into steam. The superheater's purpose is to receive the saturated steam from the boiler drum and heat it to improve its quality and to yield steam suitable for the turbine to generate electric power. The efficiency of the turbine generator is enhanced through the delivery of high-temperature steam. According to Robert Becker and David Schlotthauer of HDR Engineering, Inc., outlet superheater steam conditions at modern mass-burn and refuse-derived fuel facilities fall in the 800° to 850°F and 830 to 850 psi range. The primary purpose is to capture energy from the combustion flue gas while heating the boiler feedwater, enhancing the efficiency of the steam generating system.

The last part of the system is the turbine generator. This device converts the thermal energy of the steam to produce mechanical and then electrical energy. Exhaust steam is condensed and returned to the boiler through the feedwater system. For those waste-to-energy facilities that co-generate steam and electricity, steam is extracted from the turbine for sale to market. Steam-only facilities generally deliver low-pressure steam to nearby customers where it is

condensed to water while recovering the heat for customer use. A hot water condensate return line to the waste-to-energy plant often closes the loop.

The value of energy from waste

It is important to realize that energy production is not the foremost reason why communities turn to waste-to-energy plants to help meet their needs — protecting the public health through reliable, long-term waste disposal is the first. The generation of energy nonetheless provides important economic and environmental benefits. In addition to supplying a domestic source of renewable energy — reducing the need to rely on foreign fossil fuels — the production of energy helps to minimize the cost of service. [See box.]

Revenues from the sale of power, coupled with the facility's tipping fee, help to pay the debt service (i.e., the facility's mortgage) and the operations and maintenance costs. Other revenues may result from the sale of materials recycled on-site, prior to and after combustion, and interest on reserve funds and other sources. Energy sales alone generally account for 35 percent to 50 percent of a facility's revenues. In terms of how much power is currently generated at waste-to-energy facilities in the U.S., operating

Energy Value Index	
<u>Fuel</u>	<u>Btu/lb</u>
Mixed MSW	5,000 - 5,200
Refuse-derived fuel	5,700 - 6,200
Food	1,800 - 7,800
Paper	7,200 - 8,000
Plastics	9,500 - 18,000
Rubber	12,000 - 14,000
Textiles	8,000 - 8,800
Wood	4,700 - 7,000
Yard Waste	4,200 - 7,000
Lignite Coal	6,900
Bituminous Coal	9,000 - 14,500
#6 Fuel Oil	17,410 - 18,990
#2 Home Heating Oil	19,170 - 19,750
Natural Gas	21,800
<i>Sources: IWSA, 1992; Anthony Licata, 1992; O'Leary, Walsh, and Cross, 1987; GBB, 1985; H. Lanier Hickman, 1983; Babcock & Wilcox, 1978.</i>	

facilities have an electricity generating capacity equivalent to approximately 2,300 megawatts. This translates into an equivalent of more than 17 million megawatt-hours of exportable energy to market. When all waste-to-energy projects now under construction and in planning are considered as well, the equivalent energy generating potential is about 25 million megawatt-hours annually.

Growth potential

As noted earlier, key to the financial viability of waste-to-energy projects is the ability to sell power to utility companies and other markets. Such power purchases are required under the mandatory purchase provisions of the [federal] Public Utility Regulatory Policies Act of 1978 (PURPA).

Energy legislation passed by the U.S. Congress in October [1992] has the potential of affecting the way in which the waste-to-energy industry grows in coming years. Provisions in the comprehensive energy bill (H.R. 776) would permit greater opportunities for independent power producers (IPPs) to sell energy outside of the immediate market area in which they operate. The extent to which such enhanced transmission access opportunities will broaden markets for waste-to-energy or other independent power producers remains to be seen.

Municipal Waste Combustion in North America: 1992 Update

The recent U.S. EPA study on municipal solid waste characterization in the U.S. revealed a 42 percent increase in recycling/composting during the period of 1988 to 1990. In spite of this, the quantity of municipal solid waste requiring disposal also rose due to an increase in the total amount of waste generated. This indicates that other options are needed to help manage the 196 million tons of municipal solid waste produced annually.

United States Waste-to-energy Power Supply and Energy Saving Potential

Number WTE Facilities = 142
Net Capacity (tons per day) = 86,100

Megawatts = 2,300
Annual Megawatthours = 17.3 million
Number of homes supplied = 1.3 million
Number of Empire State Buildings Supplied = 440
Annual Number of Oil Barrels Saved = 31 million
Number of Oil Supertankers Saved = 20

Source: *Waste Age*, November 1992; IWSA, 1992

With landfill capacity expected to continue to decline, combustion of municipal solid waste at waste-to-energy (WTE) plants and non-energy recovering incinerators (collectively known as municipal waste combustors — MWC) would appear to be an obvious choice for dealing with this material.

While the quantity of municipal solid waste processed at waste-to-energy plants has grown by more than two million tons over the past year, immediate future industry growth is expected to drop off significantly. There are many reasons for this trend, including a number of projects that continue to remain on hold or that have been canceled as a result of limited financial resources or lack of project support. Another contributing factor is the lack of clear legislative and regulatory guidelines.

Clean Air Act implementation

During 1992, EPA made progress toward enacting Clean Air Act municipal waste combustion provisions signed into law by the President in November 1990. The standards will include requirements for new and existing plants, with specific emissions limits identified for lead, cadmium, mercury, and dioxins. EPA sent the draft regulations

to the Office of Management and Budget (OMB) for review in late July [1992]. Proposal of the regulations is not expected until after the November [1992] election, with enactment to follow a year later.

There are 190 municipal waste combustion plants now processing and combusting municipal solid waste in the U.S. These facilities process nearly 34 million tons annually, which represents 17 percent of the estimated 196 million tons generated in the U.S.

Of the 190 municipal waste combustion plants, 142 are waste-to-energy combustors. These facilities process 16 percent of the U.S. municipal solid waste stream. By comparison, there are 18 municipal waste combustors plants now operating in Canada processing approximately 1.7 million tons of municipal solid waste annually.

...

Controlling air emissions

With regard to what type of air pollution control equipment is found on existing waste-to-energy facilities, acid gas scrubber/fabric filter combinations and electrostatic precipitators are the two most common air pollution control systems. The municipal waste combustion regulations promulgated by U.S. EPA in February 1991 will require [sic] all existing plants with a processing capacity exceeding 250 TPD to retrofit with a scrubber system if one is not already in place.

Tough market conditions prevail

[Some] municipal waste combustion facilities [have been] recently identified as having ceased operations, proposed projects ... have been canceled, and planned projects ... are in a long-term holding pattern. In total, some 39 facilities with a rated capacity of more than 28,400 TPD fall into one of these categories. Most of the existing plants that are now closed were incinerators unable to comply with strict modern emissions standards. The cancellation of proposed projects, and the long-term holding pattern of others, often reflect an unwillingness of municipalities to make difficult, long-term municipal solid waste management decisions in favor of short-term fixes. For example, by delaying the implementation of a waste-to-energy project, communities must often rely on old systems that may be less efficient and may pose a threat to the environment.

Quantity of Municipal Waste Combustion Processed

There are more waste-to-energy plants in operation now than ever before. Clearly this technology has an important role to play as a part of the integrated waste management strategy needed to solve the garbage problem in the U.S. With time, many communities that have moved away from waste-to-energy in search of other management options can be expected to take another look. This will particularly be the case when the public sends a strong message to elected officials that short-term fixes are no longer feasible or acceptable.

Understanding Municipal Waste Combustor (MWC) Technology

Descriptions of the primary Municipal Waste Combustor technology types described in this lesson are provided below:

Incinerator: Any engineered device used in the process of controlled combustion of solid waste for the purpose of reducing the volume of the waste, destroying the combustible matter, and leaving the non-combustible ashes or residue.

There are three basic types of incinerators:

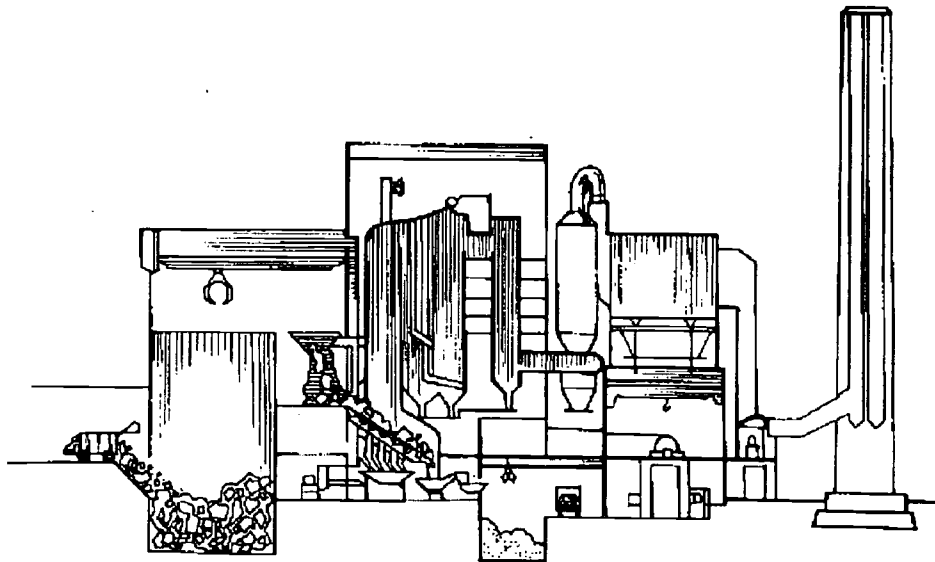
Mass Burn Incinerators (MB): Burn unprocessed, mixed solid waste in a single combustion chamber under conditions of excess air; that is more air than is needed to complete combustion if the waste could be uniformly burned.

Refuse-Derived Fuel Systems (RDF): Refuse-derived fuel refers to a wide range of pre-processed municipal solid waste. Depending on the degree of preprocessing, a variety of refuse derived fuel-fired combustors are used, including:

- Dedicated Refused-Derived Fuel Boiler: burns refuse derived fuel only
- Co-fired boiler: highly processed refuse-derived fuel co-fired with coal in coal burners
- Mixed waste firing: refuse-derived fuel fired with other waste such as wood or coal.

Modular Systems (MOD): Small, factory fabricated mass burn units that are transported to the facility site.

Waste-to-Energy: Many mass burn and refuse-derived fuel systems are designed to recovery energy. These are known as waste-to-energy facilities. Most operate by transferring the thermal energy from the hot gasses created during burning to water, making steam, in a boiler. The steam that results can be used to turn a turbine and generate electricity, or it can be used in a district heating/cooling system.



Transparency

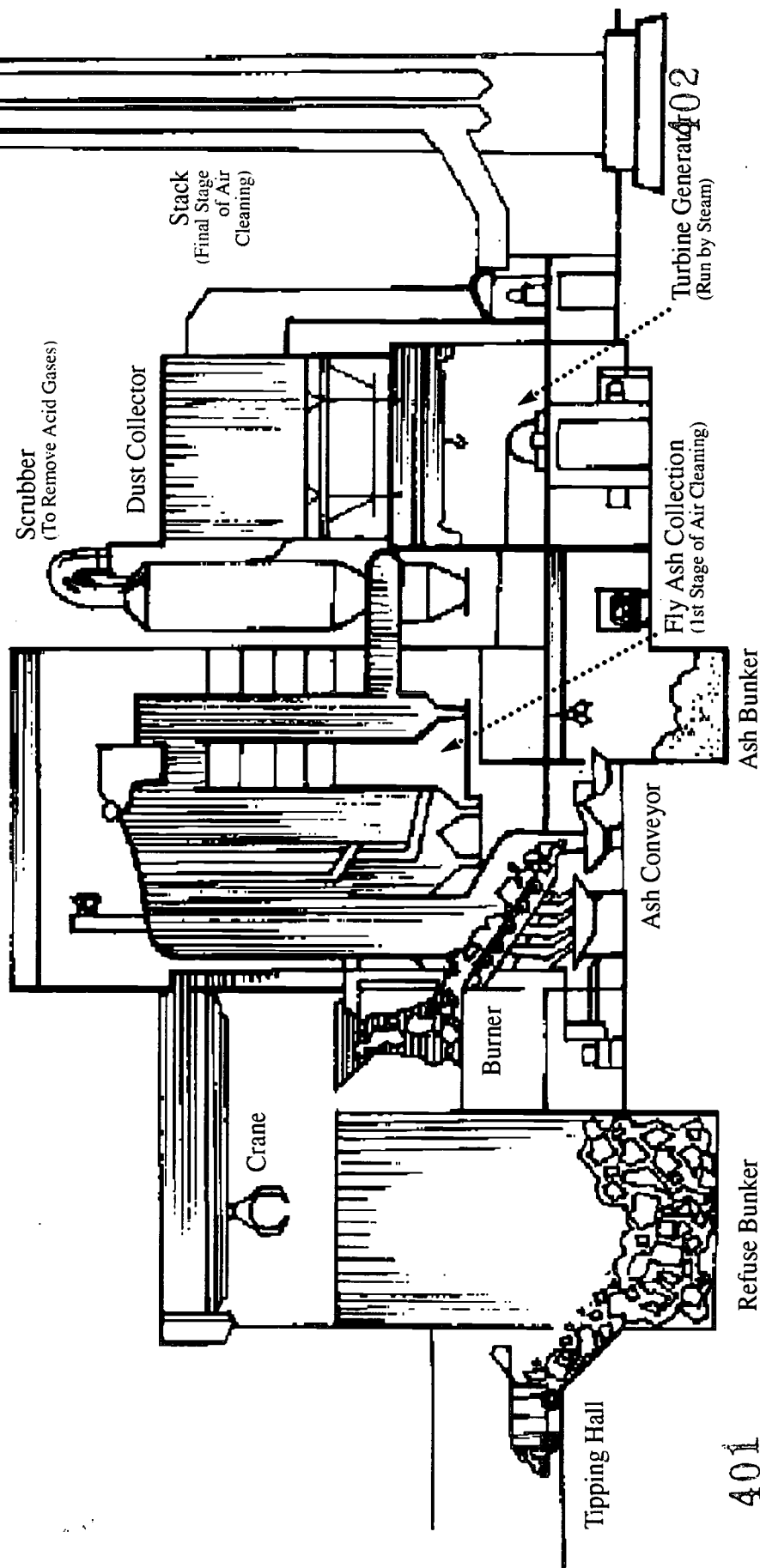
Waste-to-Energy Facility


In most waste-to-energy facilities, the procedure is similar to the following:

1. Trucks loaded with solid waste enter a tipping area and unload the trash directly into a large bin.
2. A crane then lifts the waste into a compartment where it is burned.
3. A boiler recovers the heat generated from the combustion of the waste.
4. Steam produced by the boiler is used for electric power generation.
5. The gases produced during the burning process are cleaned and discharged through the emission control system into the atmosphere.
6. The remaining ash is removed from the combustion chamber and is disposed in a secure landfill.

The U.S. EPA mandates that scrubbers must clean 99.99 percent of the waste gases and fly ash from all incinerator emissions.

The remaining ash is removed from the combustion chamber and is disposed in a secure landfill.





Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Environmental Careers

9.LC.5.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Career opportunities in environmental protection and management

Subjects: Science, Social Studies, Guidance

Materials: Environmental Publications
References, *Environmental Careers* handout

Teaching Time: Two or three class periods (not consecutive), followed by research and reporting

Environmental problems are so complicated and far-reaching that many different occupations are involved in finding solutions.

Specialists in many fields concentrate on environmental problems: sociologists may see environmental concerns as social problems; physicians, as a medical problem; teachers, as an educational problem; and so on, for many other occupations.

Environmental lobbyists promote legislation to save natural resources and try to influence legislators.

Environmental lawyers interpret laws and court decisions, as well as advise clients concerning the many problems related to the environment.

Economists predict the effects of new environmental regulation on the job market and on the costs of doing business.

Environmental engineers, hydrogeologists, biologists, and consultants serve the petroleum industry, performing environmental studies.

Other occupations include: hygienists who work to safeguard workers; engineers who specialize in safer product design and disposal techniques; and technicians who monitor the disposal processes.

There is also the new and growing field of recycling. As more cost effective and manageable ways of recycling and reusing our garbage become available, more workers will be needed in this field.

Many new environmental products and companies are currently being created by entrepreneurs.

Learning Objective

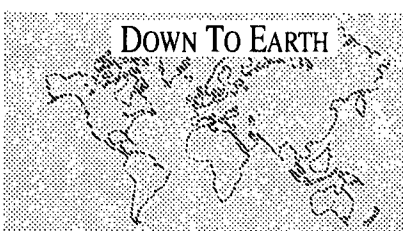
Students will:

- discover career opportunities in environmental management and protection
- identify trade magazines and professional publications as sources of career information
- develop skills in using libraries.

Background

As our awareness and knowledge about environmental problems resulting from past waste disposal have increased, both federal and state legislatures have passed bills mandating the cleanup of hazardous dump sites. Cleanup costs for the more than 600,000 toxic sites scattered across our country have been estimated at more than \$300 billion over the next 50 years. Cleanup of existing hazardous waste sites will require sophisticated technology and skilled professionals. This translates into well-paying jobs for those trained to do the work.

The current demand for all professions with skills required in environmental fields including waste disposal and Superfund-related projects is expected to increase sevenfold in the next 10 years.



South Carolina's environmental and natural resources expenditures rank 36th in the nation. The state spends \$20.50 per capita.

Source: 1994 *Environmental Almanac*

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Jobs involving environmental occupations should grow at least as fast as the economy. There are some occupations that require a high school diploma or less. The greatest demand, however, will be for technicians, operators, and professionals.

For more information about other occupations, see the guidebook entitled, *Environmental Protection Careers Guidebook*, published by the U.S. Department of Labor.

South Carolina emphasizes the waste management processes of reduction and disposal. Thus, solid and hazardous waste management is a much needed service, offering a range of employment opportunities. Recycling in South Carolina also offers opportunities for new businesses. Students can learn about these opportunities by researching trade and professional publications dealing with waste management and environmental protection.

Questions for the Class

1. Can you name three jobs/careers in environmental management and protection?
2. Can you name three publications offering information about careers in environmental management and protection?

Learning Procedure

1. Write the number \$300,000,000,000 on the board. Tell students this is the estimated cost of cleaning up hazardous dump sites over the next 50 years. Explain that jobs related to cleanup activities are expected to increase sevenfold in the next 10 years.

Discuss the South Carolina waste management priorities of reduction, recycling, treatment, incinerating, and landfilling. Explain that as industries work to implement these priorities many new jobs are expected to be created.

2. Have the class brainstorm a list of environmental management and protection occupations; for example, toxicologist, hydrologist, environmental

attorney, natural resource manager for a government agency, environmental chemist, and spill engineer.

3. Distribute the handout, *Environmental Careers*, listing the environmental management and protection occupations. Combine this list with the one just generated by the class. Have each student choose an occupation of interest.

4. Provide students with the publications listed with this lesson or give students the assignment of finding as many of these publications as possible in the nearest large library. (*You may want to alert your School Librarian prior to doing this activity.*) If your school or local library does not have or cannot obtain any of these publications, other sources are:

- South Carolina Department of Health and Environmental Control
- Municipal (City or County) Engineering Department
- Private or public waste haulers or recyclers
- Private waste management companies.

Look in the yellow pages of your local telephone book.

5. Have students research a specific environmental career using the listed publications and other appropriate sources, such as the classified ads in the Sunday newspapers of any large city. Have students prepare a report on their research that includes information on the following:

1. What do people in this profession do? Why is their work important?
2. How do people begin careers in this field?
3. What are the educational requirements for entering this field?
4. In what kinds of companies and organizations are professionals in this field employed?
5. How much money do professionals in these occupations make?
6. How do these occupations work to protect the environment?
7. What is the future outlook for this occupation?

Extension Activities

1. Have students identify companies and organizations in your area where environmental professionals are employed. Research the descriptions of the environmental jobs these companies offer. Arrange a site visit to see these professionals at work.

2. Invite an environmental professional to speak to your class. Call the South Carolina Department of Health and Environmental Control office in your area to arrange for a speaker.

3. Follow the waste stream of a particular item from its creation to its ultimate disposal and describe the jobs associated with this process. For example, chemists create a substance, chemical engineers and technicians design the processes which generate it. A toxicologist will test it to determine its potential for long-term harm to humans and animals.

Transporting it will entail certain jobs. A sanitary engineer or a biochemist might be concerned with its disposal.

Other sources of Environmental Career Information

Environmental Careers: A Practical Guide to Opportunities in the 90s, David J Warner, Lewis Publishers, Boca Raton, FL, 1992

Environmental Jobs For Scientists and Engineers, Nicholas Basta, John Wiley & Sons, Inc., New York, 1992

Green At Work: Finding A Business Career That Works For the Environment, Susan Cohn, Island Press, Washington, DC, 1992

The Environmental Careers Organization, Inc.,
286 Congress Street, 3rd Floor, Boston, MA 02210,
(617) 426-4375, provides placement and career advisement for environmental professionals.

Environmental Publications References

The editorial portions of these publications as well as the advertisements point to new career opportunities.

Chemical Week

Waste Management

EPA Journal

Buzzworm, the Environmental Journal

Waste Age

Resources Recycling

Scientific American

Garbage Magazine

E. (environmental magazine)

Science

Nature

Environmental Progress

Chemical and Engineering News

Resources and Conservation

Environmental Management

Hazardous Wastes

Public Affairs

Amicus Journal

Environmental Careers

Specific Jobs In Waste Management

A variety of technical professionals including environmental scientists; chemists; chemical, civil, environmental and mechanical engineers; environmental protection specialists; biologists; geologists; hydrologists; and others with technical skills in the physical and biological sciences are needed.

Pollution Control Engineer

These engineers plan and conduct studies to analyze and evaluate pollution problems, methods of pollution control, and methods of testing pollution sources to determine the nature and concentration of contaminants.

Resource Recovery Engineer

Engineers in this specialty conduct solid waste resource recovery studies and inspections, promote and assist in the development of resource recovery programs, coordinate marketing studies, and evaluate technology and processes.

Water Purification Chemist

In this profession, chemists analyze water in purification plants to control chemical processes that soften it or make it suitable for drinking.

Environmental Analysts

Analysts conduct research studies to develop theories or methods of abating or controlling sources of environmental pollutants, using knowledge of principles and concepts of various scientific and engineering disciplines.

Sanitary Inspector

Inspectors investigate and resolve problems of unsightly litter, weeds, and illegal dump conditions in the community.

Waste Management Engineer

Engineers in this specialization review engineering drawings, plans, and specifications; conduct inspections; and consult with management, professional, and technical personnel in order to make recommendations regarding methods and location for waste handling, processing, disposal, and resource recovery systems.

Recyclers

Many recyclers are private business owners who contract with cities and towns to collect and sell recyclables.

Waste Management Specialist

Specialists work on projects to improve solid waste disposal practices and promote the enforcement of rules and regulations.

Refuse Collection Superintendent

Superintendents are responsible for directing and coordinating the activities of refuse collection personnel within a major city.

Refuse Collection Supervisor

The supervisor exercises direct supervision over crews engaged in the collection of refuse and delivery to a disposal site.

Refuse Collection Truck Operator

Workers drive trucks and operate mechanical refuse packing equipment.

Jobs With The U.S. EPA

Most jobs in the United States Environmental Protection Agency are in the competitive service which means that applicants must compete with other candidates and be evaluated by the Office of Personnel Management. Employment in EPA is restricted by law to U.S. citizens.

Other Environmental Management and Protection Professions

Attorney
City/County Planner
City/County Recycling Education Coordinator
Environmental Consultant
Environmental Educator
Environmental Lobbyist
Environmental Planner
Environmental Technician
Environmental Researcher
Resource Geographer
Technical Writer

Plastics By The Numbers

9.LI.3.F

Preparation Time: Easy To Do Moderate Extensive

Grade: 9 - 12

Focus: Plastics recycling

Subject: Environmental Science

Materials: Collection of plastic samples, *If You Know the Code* and *Plastic Code Analysis* handouts, *Plastic Polymers* transparency

Teaching Time: Two partial class periods

Vocabulary: Code, recycle, resin



Learning Objective

Students will:

- recognize the role of plastic in our society
- understand the plastics coding system
- understand why plastic must be separated for recycling.

This activity uses the voluntary *Plastic Container Coding System* established by The Society of the Plastics Industry. The codes benefit manufacturers and recyclers, but they have application in the classroom and the home. You will find these codes on the bottom of many plastic items. Once you learn the codes, you'll find yourself examining the bottom of all kinds of plastic containers.

These plastic coding symbols — although they currently include the recycling-chasing-arrows design — do not mean that the item is recyclable. Please find out which plastics are recyclable in your area before beginning this lesson.

In South Carolina, the Solid Waste Policy and Management Act on 1991 requires this numbering system to be on all plastic packaging.

Learning Procedure

It may be beneficial to present this lesson in two parts: one to introduce plastics, assign students to look for plastics and bring in samples; and a second session on examining the types of plastics and recycling.

Part One

1. Brainstorm with the class the many uses of plastic from milk jugs to auto parts to home siding to medical applications. (*Refer to information in the Resource section on Plastics and the information included in this lesson entitled: Understanding Plastics.*)

2. Provide students with copies of the handout *If You Know The Code* and discuss how various forms of plastic are made by altering the polymer chain. See the *Plastic Polymers* transparency included with this lesson.

3. Assign students to bring in samples of the various types of plastic for the next session.

Part Two

4. Distribute copies of the *Plastics Code Analysis* handout. Have students pass around the plastic containers they have brought. Have students record



In Germany in 1987, Coca-Cola introduced a refillable 1.5-liter PET bottle. It was a huge success and Pepsi soon followed suit. Much of the resin for these bottles is manufactured here in South Carolina.

Source: "A Change in Packaging Trends,"
The BioCycle Guide to Maximum Recycling

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the required information on their sheet about each plastic item.

5. After students have examined and recorded data from all seven types of plastic, have students group the items by number and discuss.

6. What types of plastic are **recycled** in your community? Share this information with the class.

Extension Activity

Write a scenario for "A Day Without Plastics." Have students trace a typical day, the plastics they come in contact with, and what life would be like without them.

Understanding Plastics

The simple word *plastic* is a collective reference to a wide range of materials. This can cause confusion. It's no wonder: there are about 45 basic families of plastics and each can be made with hundreds of variations. Today most plastic containers are made from six primary resins. These resins are represented by the plastic container coding system.

Plastics are made from materials found in nature – petroleum, natural gas, and coal. Basic compounds of carbon, hydrogen, oxygen, and nitrogen are extracted and combined to produce many kinds of plastic **resin**.

Plastics come in three basic forms. One form is *thermoset* plastics, which can be heated and molded only once. These plastics are not degradable. Automobile bodies and bakelite used in nonstick cookware are examples of thermoset plastics.

The second type of plastics, *thermoplastics* (plastic milk jugs, etc.), are recyclable and not degradable. They may be remolded several times. Some reuses for thermoplastics are boat docks, pallets, and filler for insulation in ski jackets.

The newest type of plastics are *degradables*. Some degradables can be broken down by light, others by salt, and still others by biodegradation. Degradable plastics are not recyclable.

The popularity and wide use of plastic can be attributed to its wide range of properties and design possibilities.

At Home, plastic:

- protects products
- resists breakage
- makes handling easier
- allows tamper protection
- adds convenience
- allows use of lightweight windows, pipes, flooring.

At Work, plastic is found in:

- furniture and upholstery
- classroom erasable boards
- assembly line parts that don't corrode
- lightweight automotive parts
- fax machines
- computers
- copiers.

At Play, plastic is used to make:

- toys
- movies
- safety helmets, mouth guards
- boats
- dome stadiums
- campers
- playground equipment.

In Health Care, plastic is used for:

- artificial hearts
- artificial limbs
- contact lenses
- X-ray film
- filtering devices
- tubing
- special disposable items that help guard against infection and contamination.

Did you know?








- Pound for pound, plastic products account for only about 9.3 percent of municipal solid waste. Yard and food waste, by comparison, account for about 22.6 percent of the solid waste stream. Paper and paperboard account for about 37.6 percent.
- Plastic beverage containers have the second highest "scrap value" of recyclable materials in packaging – next to aluminum.
- Plastic products have the highest energy value for modern waste-to-energy incineration. For example, the energy content of a pound (454 g) of polyethylene is 19,900 Btu. A pound (454 g) of Wyoming coal has an energy value of 9,600 Btu.
- Plastic products have already contributed substantially to source reduction in the waste stream by replacing heavier, thicker materials previously used in packaging. This is accomplished by engineered reductions in the amount of plastic used in containers such as the soft drink bottle.
- About 28 percent of all plastic soft drink containers, more than 190 million pounds (86,183 metric tons), were recycled in 1989 into new consumer products, and the demand for recycled plastic is growing. Seventy million pounds (31.7 metric tons) of the plastic used in milk containers were recycled in 1989.
- Only five recycled soda bottles makes enough fiberfill for one ski jacket.
- Americans discard at least \$120 million worth of recyclable milk jugs, butter tubs and other #2 HDPE plastics each year.
- Every year we make enough plastic film to shrink-wrap Texas.



IF YOU KNOW THE CODE ... You can tell what resin the product is made from.

To make recycling easier, plastics manufacturers are now using a **standard coding system** on single-use plastic containers to identify the **resin type** (the artificial substance similar to natural resin from trees). Since plastic recycling opportunities are different throughout the country, consumers should find out which types of plastics are recycled in their communities and make purchases and recycle accordingly. The plastic type used for many typical products is changing as more manufacturers move to packaging using Number 1, PET, and Number 2, HDPE. PET and HDPE are the most common plastics recycled in South Carolina.

Plastic Container Code System For Plastic Containers


<u>Symbol/Code</u>	<u>Material</u>	<u>Typical Products</u>	<u>Can Be Recycled Into</u>
 PET or PETE	Polyethylene terephthalate	soft drink bottles, peanut butter jars, cooking oil & ketchup bottles.	carpets, surfboards, sailboat hulls, strapping
 HDPE	High-density polyethylene	milk, water & juice jugs, detergent bottles. About 40% of all bottles.	trash cans, base caps for soda bottles, detergent bottles, drain pipes
 V	Vinyl/polyvinyl chloride (PVC)	some shampoo bottles, molded hardware packaging.	fencing, handrails, house siding
 LDPE	Low-density polyethylene	dry cleaning, bread & trash bags, some squeeze bottles.	grocery bags, garbage can liners
 PP	Polypropylene	yogurt cups, straws. 5% to 10% of bottles.	birdfeeders, pails, water-meter boxes, car-battery cases
 PS	Polystyrene	egg cartons, meat trays, coffee cups, carryout containers, video tapes.	pencil holders, tape dispensers, license-plate frames, trays
 Other	All other resins and layered multi-material	microwavable serving ware.	benches, picnic tables, roadside posts, marine pilings

NOTE: Plastics recycling technologies continue to change. More and more products are being made from PET and HDPE because of their acceptance in recycling programs. In addition, new uses for recycled plastic are being introduced.

Plastic Code Analysis

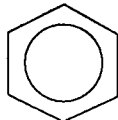
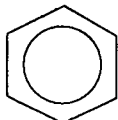
Name _____

Date _____

 Number Symbol	<i>PET or PETE</i> <i>HDPE</i> <i>V or PVC</i> <i>LDPE</i> <i>PP</i> <i>PS</i> <i>other</i> Letter Code	<i>In this column write the name of the product</i> Product Name	<i>Describe the package using terms such as: flexible, rigid transparent, opaque translucent, color white creases form when crushed</i> Package Properties

Plastic Polymers

Polymers are very large, usually chain-like molecules built from many small molecules (monomers) held together by strong chemical bonds. Polymers form the basis for synthetic fibers, rubbers, and plastics – all of which are carbon-hydrogen derivatives. Some of the polymers that are of concern in solid waste disposal are listed below with their chemical formulas and uses.

<u>NAME</u>	<u>SKELETON FORMULA</u>	<u>POLYMER FORMULA</u>	<u>USES</u>
Polyethylene HDPE #2 LDPE #4	Ethylene $\text{H}_2\text{C} = \text{CH}_2$	$-(\text{CH}_2-\text{CH}_2)-n$	Plastic Pipes Bottles Toys
Polystyrene Code #6	Styrene $\begin{array}{c} \text{H} \\ \\ \text{H}_2\text{C} = \text{C} \\ \\ \text{C}_6\text{H}_5 \end{array}$ 	$\begin{array}{c} \text{H} \\ \\ -(\text{H}_2\text{C} - \text{CH})-n \\ \\ \text{C}_6\text{H}_5 \end{array}$ 	Thermal insulated <ul style="list-style-type: none"> • Trays • Plates • Bowls
Polystyrene (aerated styrene) Vinyl Chloride	$\begin{array}{c} \text{H} \\ \\ \text{H}_2\text{C} = \text{C} \\ \\ \text{Cl} \end{array}$	Polyvinyl Chloride $\begin{array}{c} -(\text{H}_2\text{C} - \text{CH})-n \\ \\ \text{Cl} \end{array}$	PVC Pipe Siding Floor tile Clothing Toys

Polyethylene can be in the form of high density polyethylene (HDPE, milk jugs, detergent containers, etc.) and low density polyethylene (LDPE, shopping and garbage bags) which differ only in the compactness of the molecule. Although polymers are insoluble in water, there are solvents that will cause polymers to decompose. However, these solvents ... toluene, acetone, and ether ... are harmful to humans, animals, and the environment.

Sea of Plastics

9L1.2.F

Preparation Time: Easy-To-Do Moderate Extensive

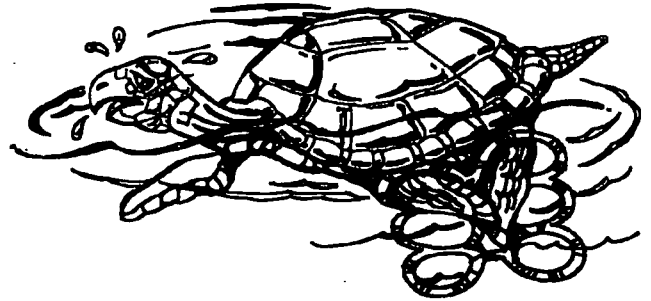
Grade: 9 – 12

Focus: Negative effects of litter on wildlife

Subjects: English, Environmental Science, Biology

Materials: Samples of plastic litter, Plastic pellets, Work Sheets and Reading Selections

Teaching Time: Several Class Periods



Learning Objectives

Students will :

- identify pertinent information regarding the effects of plastic waste on wildlife
- determine individual actions which can help reduce the magnitude of the problem.

In this lesson students read segments of a magazine article about plastics and wildlife, and share pertinent information from their segment with the class. *Plastics at Sea* by D.H.S. Wehle and Felicia C. Coleman is reprinted from Natural History, Vol. 92, No. 2; Copyright the American Museum of Natural History, 1983. This is an advanced reading selection. Students may need to use a dictionary. In the years since this article was written, public awareness of the potential harm of litter on wildlife has increased dramatically.

Although some of the information in this reading selection is somewhat dated, it is a good explanation of the impacts of waste on marine life.

Plastics in the sea is a relatively minor solid waste issue, but it does continue to pose a threat to some marine life. An estimated 14 billion pounds of all types of trash are dumped into the sea each year. In 1992 volunteers for the Center for Marine

Conservation picked up 2.5 million pounds (1,134 metrics tons) of trash off 3,800 miles (6,115 kilometers) of United States coastline ... 60 percent of it was plastic.

In South Carolina, during the 1993 Beach Sweep/River Sweep 7,232 volunteers collected 79 tons of debris from the edges of the state's river and ocean waters' edge during a three-hour period on September 18, 1993. In 1994, 5,757 volunteers collected nearly 60 tons of debris, including plastics, glass, and paper. Much of what was collected was recycled.

Materials

Plastics at Sea reading sections (one copy of assigned section per student), *Plastic Trash & Wildlife* worksheet (one per student), and teacher sheet. Samples of potentially harmful plastic trash — plastic bags, plastic six-pack holders, plastic fishing nets, monofilament fishing line.



In July 1993, a Princess Cruise ship was fined \$500,000 when the crew heaved 20 plastic bags of garbage overboard as the ship sailed off the Florida coast. Passengers videotaped the incident and reported it to authorities.

Source: 1994 *Environmental Almanac*

9-12
PAGE
199

Background

Since the early 1970's, the amount of plastic in the marine environment has increased dramatically. Plastics endanger marine life through two processes: strangulation and ingestion of plastic material.

According to a study documenting the environmental advantages of glass over plastic containers based on published information published in 1993 by Henry S. Cole, Ph.D and Kenneth A. Brown, "The very properties that make plastics useful, its light weight and durability, are at the root of the problems they pose to marine life. Plastic disposed of in the ocean not only lasts for a long time (many months to years), but it also floats. Thus, it can be transported by ocean currents for long distances to beaches and biologically productive coastal waters. Plastic contamination of ocean waters is a fairly recent phenomena — it has undoubtedly grown as a direct result of the enormous growth in plastic production during the past 30 to 50 years.

"The impact of plastics on the marine environment has been so severe that the international treaty protecting marine life (the MARPOL Convention) and its implementing legislation in the U.S. have banned the disposal of all plastics in ocean waters and in U.S. navigable waters. To comply with these laws, the U.S. Navy has drastically reduced its use of plastic packaging."

Some animals, mistaking plastic for food, eat it. For example, approximately 15 percent of the world's 280 species of sea birds are known to have eaten plastic in the form of pellets, bits of polystyrene, even plastic toy soldiers. In addition, sea turtles, apparently regarding plastic bags as jellyfish upon which they regularly feed, have been found with balls of plastic in their stomachs. Other animals found to have eaten plastic in one form or another are whales, dolphins, bottom fish, manatees, sea snails and worms, and plankton.

Another damaging effect of plastic trash on wildlife is the entanglement of animals in everything from

six-pack holders to plastic rings, discarded fishing line, and nets.

Learning Procedure

1. Pass around samples of potentially harmful plastic trash and ask students how such trash might effect wildlife.
2. Divide students into 10 groups. Each group will be responsible for reading and discussing one section of a scientific article about plastic trash and wildlife.
3. Distribute copies and assist students with difficult terms if necessary. Encourage students to look up the definitions of unfamiliar terms in a dictionary.
4. When all groups have finished reading and discussing their sections, distribute the *Plastics At Sea* worksheet. Instruct each group to share pertinent information from its section of the reading with the class. Students should then use this information to answer the worksheet questions.
5. Conclude the class with a discussion of major concepts addressed in the reading. Stress the following ideas:
 - The plastics at sea problem is a global one and solving the problem will require international cooperation.
 - There are many things the plastic industry and consumers of plastic can do to help solve the problem.
 - The first step in combating the plastic pollution problem is education.

For additional readings, see *A Citizen's Guide to Plastics in the Ocean: More than a Litter Problem*, published by the Center for Marine Conservation.

Evaluation

1. Collect completed worksheets and compare student responses with those on the teacher sheet.
2. Have students identify at least two individual actions they can take to help solve the plastic pollution problem.

Extension Activity

As a class, participate in a Beach/River Cleanup Program. Information about beach and river clean-ups is available in a six-page brochure called "The Coastal Connection." The brochure is available through the Center for Marine Conservation, 1725 DeSales Street, N.W., Washington, D.C., 20036; (202) 429-5609. They publish, *A Citizen's Guide to Plastics in the Ocean: More Than a Litter Problem*.

For more information about South Carolina's Beach and River Sweep Programs call or write:

S.C. Department of Natural Resources
Water Resources Beach/River Sweep
1201 Main Street, Suite 1100
Columbia, South Carolina
(803) 737-0800

OR

S.C. Sea Grant Consortium
Beach Sweep
287 Meeting Street
Charleston, South Carolina 29401

These programs offer a variety of information and opportunities for participation. While sweeps are held in September, interested participants should contact them as early as possible.

If the Shoe Drifts

from the 1994 *Environmental Almanac*

Nike, the sportswear and shoe manufacturer, showers sports stars with huge profits for endorsing its products. Nike also unwittingly made a sizable contribution to ocean litter – and to oceanography as well.

In 1990, about 800 miles west of Seattle, a container ship lost a load of 40,000 pairs of Nike shoes in a storm. Two Seattle oceanographers who study ocean currents heard about the incident and started keeping track of where the floating shoes washed up. Beachcombers from southern Oregon to Canada's Queen Charlotte Islands reported shoe findings to the scientists, who compared data with a computer model that predicts current patterns in the North Pacific.

The study is ongoing. Some Nikes are still afloat, bound for the Aleutians and Japan. As they travel and further reports drift in, oceanographers hope to add to what they know about the ocean's sometimes mysterious movements.

GROUP 1 READING SECTION

Throughout the 1970's, a number of biologists studying the feeding habits of sea birds in different oceans of the world recounted the same story: the birds were eating plastic.

Similar reports of plastic ingestion and of entanglement in plastic debris began to surface for other marine animals — fish off southern New England, turtles off Costa Rica and Japan, whales in the North Atlantic. At the same time, plastic particles turned up in surface plankton samples from both the Atlantic and Pacific oceans; plastic debris was retrieved by benthic (bottom) trawls in the Bering Sea and Britain's Bristol Channel; and plastic pellets washed ashore in New Zealand in such large numbers that some beaches were literally covered with *plastic sand*.

By the close of the decade, marine scientists around the world had become aware of a new problem of increasing ecological concern: plastics at sea.

Two forms of plastic exist in the marine environment: *manufactured* and *raw*. Manufactured plastic material along beaches and adrift at sea is primarily refuse from transport, fishing, and recreational vessels. In 1975, the National Academy of Sciences estimated that commercial fishing fleets alone dumped more than 52 million pounds of plastic packaging material into the sea and lost approximately 298 million pounds of plastic fishing gear, including nets, lines, and buoys.

Raw plastic particles - spherules, nibs, cylinders, beads, pills, and pellets - are the materials from which products are manufactured. These particles, about the size of the head of a wooden match, enter the ocean via inland waterways and outfalls from plants that manufacture plastic. They are also commonly lost from ships, particularly in the loading and unloading of freighters. Occasionally, large quantities are deliberately dumped into the sea.

GROUP 2 READING SECTION

Plastics turn up everywhere. Along portions of the industrialized coast of Great Britain, concentrations of raw particles have reached densities of about 2,000 pieces per square foot in benthic (bottom) sediments. Near Auckland, New Zealand, 100,000 pieces of plastic were found every three lineal feet of beach. Particles have also washed ashore on beaches in Texas, Washington, Portugal, Colombia, Lebanon, and at such remote sites as the Aleutian and Galapagos Islands.

Much of what we know about the distribution patterns and abundance of raw plastic in the world's oceans comes from plankton sampling of surface waters. Between 1972 and 1975, for example, the Marine Resources Monitoring, Assessment, and Prediction Program, a nationally coordinated program of the National Marine Fisheries Service, recorded plastic particles in plankton samples collected between Cape Cod and the Caribbean Sea. The majority of the particles were found to have entered the ocean from the coast of southern New England, and the highest concentrations were usually in coastal waters.

Raw plastic, however, was ubiquitous in the open ocean and especially common in the Sargasso Sea. This suggests that winds and currents are instrumental in redistributing and concentrating particles in certain oceanographic regions.

Inevitably, many animals foraging in the marine environment will encounter and occasionally ingest these widely distributed plastic materials.

One of the first records of plastic ingestion appeared in 1962 for an adult Leach's storm petrel collected off Newfoundland. Four years later, researchers in the Hawaiian Islands found that the stomach contents of young Laysan albatrosses contained plastic, apparently fed them by their parents.

GROUP 3 READING SECTION

For the most part, early reports (of plastic ingestion and entanglement) were treated as curious anecdotes included in studies of the feeding ecology of a few sea birds.

During the 1970's and early 1980's, however, with the proliferation of such anecdotes, biologists began paying closer attention and were surprised to find how frequently plastic occurred in the stomach contents of certain Procellariids from the North Pacific and the North Atlantic (short-tailed shearwaters, sooty shearwaters, and northern fulmars) and alcids from the Northern Pacific (parakeet auklets and homed puffins). Lower frequencies were reported for other Northern Hemisphere sea birds, including phalaropes, gulls, terns, and also other procellariids and alcids. The feeding habits of marine birds in southern oceans have not been studied as extensively, but plastic ingestion has been documented for several species of procellariids (petrels, shearwaters, and prions) in the South Atlantic, South Pacific, and subantarctic water.

To date, about 15 percent of the world's 280 species of sea birds are known to have ingested plastic.

Sea birds choose a wide array of plastic objects while foraging: raw particles, fragments of processed products, detergent bottle caps, polyethylene bags, and toy soldiers, cars, and animals. Marine turtles on the other hand, consistently select one item - plastic bags. In the past few years, plastic bags have been found in the stomachs of four of the seven species of marine turtles: leatherbacks from New York, New Jersey, French Guiana, South Africa, and the coast of France; hawksbills on the Caribbean coast of Costa Rica, greens in the South China Sea and in Japanese, Australian, and Central American coastal waters; and olive ridleys in the Pacific coastal waters off Mexico. Evidence points to plastic ingestion in loggerheads, as well, based on liver samples containing high concentrations of a plasticizer (a chemical compound added to plastic to give it elasticity). Polystyrene spherules have been found in the digestive tracts of one species of chaetognath (transparent, worm-like animals) and eight species of fish in southern New England waters. They have also turned up in sea snails and in several species of bottom-dwelling fishes in the Severn Estuary of southwestern Great Britain.

GROUP 4 READING SECTION

Marine mammals are not exempt from participation in the plastic feast. Stomachs of a number of beached pygmy sperm whales and rough-toothed dolphins, a Cuvier's beaked whale, and a West Indian manatee contained plastic sheeting or bags. In addition, Minke whales have been sighted eating plastic debris thrown from commercial fishing vessels. Curiously, plastic has not been found in any of the thousands of ribbon, bearded, harbor, spotted, ringed, or northern fur seal stomachs examined from Alaska.

The obvious question arising from these reports is, why do marine animals eat plastic? In the most comprehensive study to date, Robert H. Day of the University of Alaska maintains that the ultimate reason for plastic ingestion by Alaskan sea birds lies in plastic's similarity - in color, size, and shape - to natural prey items. In parakeet auklets examined by Day, for example, 94 percent of all the ingested plastic particles were small, light brown, and bore a striking resemblance to the small crustaceans on which the birds typically feed.

Marine turtles also mistake plastic objects for potential food items. Transparent polyethylene bags apparently evoke the same feeding response in sea turtles as do jellyfish and other medusoid coelenterates, the major food item of leatherbacks and subsidiary prey of greens, hawkbills, loggerheads, and ridleys.

Sea birds, marine turtles, and marine mammals all eat plastic. So what? Perhaps ingesting plastic is inconsequential to their health. After all, cows are known to retain nails, metal staples, and strands of barbed wire in their stomachs for more than a year with no ill effects. For marine animals, however, the evidence is growing that in some cases at least, ingested plastic causes intestinal blockage. George Hughes of the National Parks Board, South Africa, extracted a ball of plastic from the gut of an emaciated leatherback turtle; when unraveled, the plastic measured nine feet wide and twelve feet long. There is little doubt that the plastic presented an obstruction to normal digestion. Similarly, a mass mortality of green turtles off Costa Rica has been attributed to the large number of plastic banana bags eaten by the turtles.

GROUP 5 READING SECTION

The 20 dead red phalaropes discovered on a beach in southern California, all with plastic in their digestive tracts, present a less clear case (regarding the effect of plastic ingestion on animal health). Did the birds suffer an adverse physiological response after eating plastic or were they already under stress because of a reduced food supply and eating the plastic in a last-ditch effort to prevent starvation? The same question applies to other instances of emaciated animals that have eaten plastic. At this time, we don't have an answer.

We do know that plastic is virtually indigestible and that individual pieces may persist and accumulate in the gut. Ingested plastic may reduce an animal's sensation of hunger and thus inhibit feeding activity. This, in turn, could result in low fat reserves and an inability to meet the increased energy demands of reproduction and migration. Plastic may also cause ulcerations in the stomach and intestinal linings, and it is suspected of causing damage to other anatomical structures. Finally, ingestion of plastic may contribute synthetic chemicals to body tissues. Some plasticizers, for example, may concentrate in fatty tissues, their toxic ingredients causing eggshell thinning, aberrant behavior, or tissue damage. When highly contaminated tissues are mobilized for energy, these toxins may be released in lethal doses.

Publication of data on plastic ingestion is in its infancy. As the problem gains notoriety, it will certainly be revealed to be even more widespread than is now recognized. There are already several known instances of secondary ingestion, in which plastic consumed by animals feeding at low trophic levels shows up in higher-level consumers. The remains of a broad-billed prion, together with the plastic pellets it had ingested, were found in the castings of a predatory South Polar skua in the South Atlantic. Plastic pellets found in the Galapagos Islands were traced from transport vessels in Ecuadorean ports through a food chain involving fish, blue-footed boobies, and short-eared owls.

GROUP 6 READING SECTION

A more obvious effect of plastic pollution is the aesthetic one. Whether we venture deep into the woods, high atop a mountain, or out on the ocean to escape the trappings of civilization, our experience of the natural world is often marred by the discovery of human litter. Even more disturbing to the spirit is the sight of a young pelican dangling helplessly from its nest by a fishing line, a whale rising to the surface with its flukes enshrouded in netting, or a seal nursing wounds caused by a plastic band that has cut into its flesh. Unfortunately, such observations are becoming more and more common, another consequence of plastics at sea.

During the last 20 years, fishing pressure has increased dramatically in all the world's oceans, and with it, the amount of fishing-related debris dumped into the sea. In addition, the kind of fishing equipment finding its way into the ocean has changed. Traditionally, fishing nets were made of hemp, cotton, or flax, which sank if not buoyed up. These materials disintegrated within a relatively short time and, because of the size of the fibers, were largely avoided by diving sea birds and marine mammals. With the advent of synthetic fibers after World War II, however, different kinds of nets came into use. These new nets were more buoyant and longer-lived than their predecessors, and some of them were nearly invisible under water.

The result of these changes in net materials has been a tragic increase in mortality of air-breathing animals. A few examples are sufficient to give an idea of the magnitude of the problem. During the heyday (1972-76) of the Danish salmon fishery in the North Atlantic, the incidental catch of thick-billed murrelets amounted to three-quarters of a million birds annually; in 1980, 2,000 sea turtles off the southeastern coast of the United States drowned when incidentally caught in shrimp trawl nets. Incidental catch refers to nontarget animals that are accidentally caught in an actively working net. Another kind of net-related mortality is known as entanglement and refers to any animal caught in a net that has been lost or discarded at sea. Some government officials estimate that about 50,000 northern fur seals currently die in the North Pacific each year as a result of entanglement in fishing gear. Unlike working nets, which fish for specific periods of time, these free-floating nets, often broken into fragments, fish indefinitely. When washed ashore, they may also threaten land birds and mammals; in the Aleutian Islands, for example, a reindeer became entangled in a Japanese gill net.

GROUP 7 READING SECTION

Plastic strapping bands - used to secure crates, bundles of netting, and other cargo - are another common form of ship-generated debris. Discarded bands are often found girdling marine mammals, which are particularly susceptible to entanglement because of their proclivity for examining floating objects. The instances of seal entanglement in plastic bands has increased so remarkably in the past two decades that fur seal harvesters in Alaska and South Africa now monitor the number of ringed animals.

Sea birds that frequent recreational waters or coastal dumps are also subject to ringing by the plastic yokes used in packaging six-packs of beer and soda pop. Gulls with rings caught around their necks are sometimes strangled when the free end of the yoke snags on protruding objects. Similarly, pelicans, which plunge into the water to feed, run the risk of diving into yokes. If the rings become firmly wedged around their bills, the birds may starve.

Not all encounters with plastic prove harmful to marine organisms. Some animals are incorporating the new material into their lives. Algae, hydrozoans, bryozoans, polychaetes (marine worms), and small crustaceans attach to plastic floating at sea; bacteria proliferate in both raw and processed plastic refuse. Plastic provides these organisms with long lived substrates for attachment and transport; in some cases, hitching a ride on floating pieces of plastic may alter an organism's normal distribution. Several species of tube-dwelling polychaetes construct the tubes of raw plastic particles present in benthic (bottom) sediments. Other invertebrates such as sand hoppers and periwinkles, find temporary homes in aggregates of plastic particles they encounter on beaches. Marine birds all over the world incorporate plastic litter into their nests, but in this case, the use of plastic may be harmful because chicks can become entangled in the debris and die.

GROUP 8 READING SECTION

Instances of marine animals adapting to this new element (plastic) in their environments do not alter the predominately negative effect of plastics at sea. The problem is global and its solution will require international cooperation. Historically, the high seas have, in many respects, been considered an international no-man's land. Recently, however, perception of the ocean as a finite and shared resource has caused many nations to express concern for its well-being.

In 1970, the U.S. Congress passed the National Environmental Policy Act which, among other things, pledged to encourage productive and enjoyable harmony between man and his environment. Subsequently, a number of laws on waste disposal were adopted, two of which affect pollution by plastics: the Federal Water Pollution Control Act (commonly known as the Clean Water Act) and the Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act). The Clean Water Act does not specifically address the problem of persistent plastics but does require all significant polluters of U.S. waterways to obtain a federal permit, under which limits are set on, among other things, discharges of solid matter. The Ocean Dumping Act prohibits the deliberate dumping of significant amounts of persistent plastic materials at sea. Having these laws on the books, however, does not immediately solve the problem. Small-scale refuse disposal on the high seas is difficult to regulate; fishermen who claim to have unintentionally lost their nets at sea cannot be held responsible; and illegal large-scale dumping at sea is hard to detect. Granted, laws must be tightened, but enforcement is really the bigger problem.

On the international level, the problems of water pollution and litter in the oceans were highlighted at the United Nations Conference on the Human Environment held in Stockholm in 1972. The conference, with 110 nations represented, defined the need for international policy on marine pollution among coastal and maritime nations. Treaties to implement such policy soon followed: the 1972 London Convention on the Prevention of Water Pollution by Dumping of Wastes and Other Matter (Ocean Dumping Convention), a part of which specifically prohibits marine dumping of persistent plastic material; and the 1973 London International Convention for the Prevention of Pollution from Ships (Marine Pollution Convention), which is broader in scope and regulates the control of oil pollution, packaged substances, sewage, and garbage. While neither of these treaties has been adopted by all nations, they represent a start toward global control of marine pollution.

GROUP 9 READING SECTION

The quantity of plastics in the world's oceans will undoubtedly continue to mount. Ironically, the very characteristics that make plastic appropriate for so many uses - its light weight, strength, and durability - lead to the majority of problems associated with its presence at sea.

As organic material, plastic is theoretically subject to degradation by mechanical, oxidative, or microbial means. Owing to the strength of most plastics, however, mechanical degradation by wave action is generally restricted to the breaking of large pieces into smaller ones.

Photo-oxidation and microbial action are limited by plastic's high molecular weight and its antioxidants, ultraviolet light stabilizers, and biocide additives, which effectively immunize it against degradation. The longevity of plastics in seawater is not known, but on the beach, particles may last from five to more than 50 years.

Given plastic's long life and projected annual increases in production, one thing is clear - the rate of plastic deposition in the marine environment will continue to be higher than the rate of disappearance.

In a study of the accumulation of plastic on the beaches of Amchitka Island, Theodore R. Merrell, Jr., of the National Marine Fisheries Service, recorded that 550 pounds of plastic litter were added to less than a mile of beach in one year. He also found an increase of more than 250 percent in both the number and the weight of plastic items washed ashore over a two-year period.

GROUP 10 READING SECTION

Outside the realm of laws and treaties, solutions to the (plastics at sea) problem can come from both inside and outside the plastic industry. The technology to manufacture degradable plastics is available. In fact, one of the beauties of plastic is that its properties can be altered and its life expectancy prescribed.

Many states have already taken steps toward reducing plastic litter by requiring that plastic six-pack yokes be made of a self-destructing compound. Another, but perhaps less workable solution, given the logistics and expense involved and the degree of business and public cooperation required, lies in recyclable plastics. At the very least, all countries should require that the discharge of raw plastic particles from industrial plants be reduced by filtering outflow before it enters waterways.

A recent decline in the uptake of plastic by marine organisms in southwestern England has been attributed, in part, to the efforts of one of the major contaminating plants to filter, collect, and reuse raw particles present in its effluent.

Consumers share with industry the responsibility to reduce the amount of plastic in the sea. Recreational boaters, beach-goers, and commercial fishermen all discard plastic refuse. Preferably, no trash plastic - bands, netting, or other debris - should ever be tossed overboard or left on a beach. If six-pack yokes or strapping bands must be discarded at sea, the rings should be cut first so that they pose less of a threat to marine animals.

The first step in combating plastic pollution is to alert both industry and the general public to the gravity of the problem and the need to do something about it soon. Education alone cannot solve the problem but it is a beginning. Public awareness of a problem, combined with the resolve to correct it, can bring dramatic results.

Plastic Trash and Wildlife

Group 1 Questions

1. During what decade did scientists around the world first become aware of the “plastics at sea” problem?
2. What are the two forms of plastics found in the sea?
3. In 1975, how many estimated pounds of plastic packaging material were dumped into the sea by commercial fishing fleets?

Group 2 Questions

4. Where have plastics from the sea eventually turned up?
5. Where do the majority of U.S. plastic particles enter the Atlantic Ocean?
6. What two factors are instrumental in redistributing and concentrating plastic particles in certain regions of the sea?

Group 3 Questions

7. What percent of the world’s 280 species of sea birds are known to have ingested plastic?
8. What type of plastic do marine turtles consistently select to eat?
9. In what types of animals has raw plastic (polystyrene spherules) been found?

Group 4 Questions

10. Name three types of marine mammals that eat plastic.
11. Why do marine animals eat plastic?
12. How can eating plastic harm marine turtles?

Group 5 Questions

13. Plastic accumulates in the guts of animals and persists forever because plastic is *(complete this sentence)*.
14. When plasticizers (chemicals in plastic) concentrate in fatty tissues of animals, what harmful effects can they cause?
15. When plastic eaten by animals at low levels of the food chain shows up in animals at higher levels of the food chain, it is called *(complete this sentence)*.

Group 6 Questions

16. When nontarget animals are accidentally caught and drowned in fishing nets, it is called an *(complete this sentence)*.
17. When animals get caught and die in nets that have been lost or discarded at sea, it is called *(complete this sentence)*.
18. How many estimated northern fur seals die in the North Pacific each year as a result of entanglement?

Group 7 Questions

19. How can six-pack rings harm animals?
20. How do sand hoppers and periwinkles use plastic?
21. How can using plastic litter in nests harm birds?

Group 8 Questions

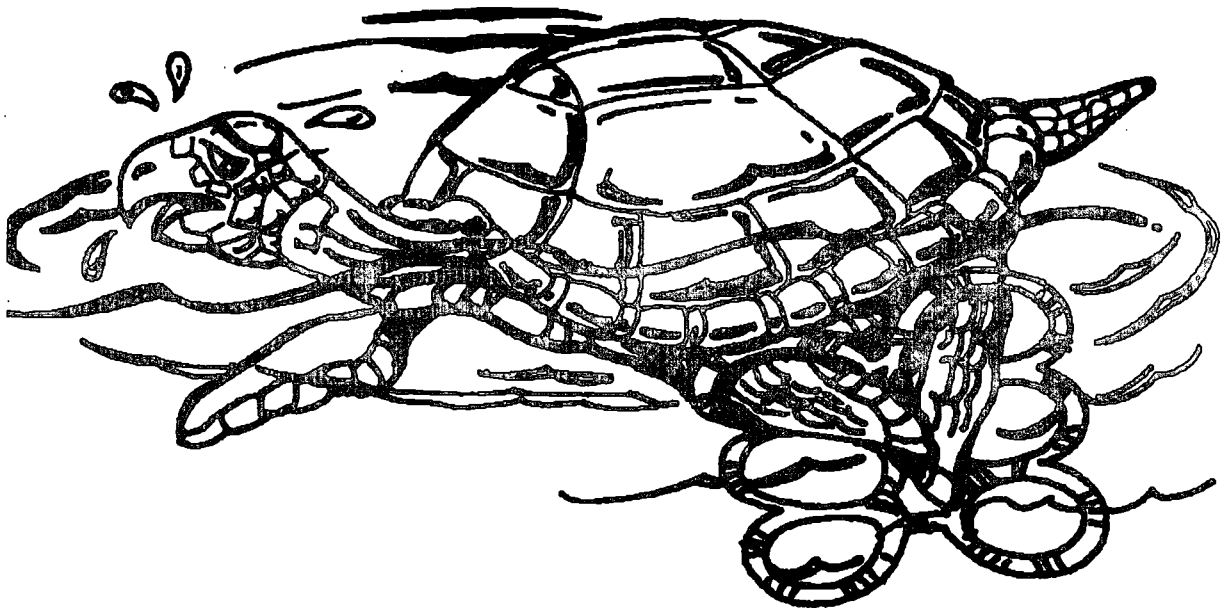
22. What will be required to solve the plastics at sea problem?
23. What two U.S. laws affect pollution by plastics?
24. What two international treaties address the marine pollution problem?

Group 9 Questions

25. What three characteristics make plastic so useful for man and so dangerous for sea life?
26. How long may plastic particles on the beach last?
27. On Amchitka Island, how many pounds of plastic litter were added to less than a mile of beach in one year?

Group 10 Questions

28. Name one way the plastic industry can help solve the plastics at sea problem.
29. How can consumers reduce the amount of plastic in the sea?
30. What is the first step in combating plastic pollution?



Plastic Trash and Wildlife

Group 1 Questions

1. During what decade did scientists around the world first become aware of the plastics at sea problem? **(1970's)**
2. What are the two forms of plastics found in the sea? **(manufactured and raw)**
3. In 1975, how many estimated pounds of plastic packaging material were dumped into the sea by commercial fishing fleets? **(52 million pounds)**

Group 2 Questions

4. Where have plastics from the sea eventually turned up? **(everywhere)**
5. Where do the majority of U.S. plastic particles enter the Atlantic Ocean? **(the coast of southern New England)**
6. What two factors are instrumental in redistributing and concentrating plastic particles in certain regions of the sea? **(winds and currents)**

Group 3 Questions

7. What percent of the world's 280 species of sea birds are known to have ingested plastic? **(15)**
8. What type of plastic do marine turtles consistently select to eat? **(plastic bags)**
9. In what types of animals has raw plastic **(polystyrene spherules)** been found? **(chaetognath, fish, and sea snails)**

Group 4 Questions

10. Name three types of marine mammals that eat plastic. **(whales, dolphins, and manatees)**
11. Why do marine animals eat plastic? **(plastic looks like the animal's natural food)**
12. How can eating plastic harm marine turtles? **(it can block their intestines)**

Group 5 Questions

13. Plastic accumulates in the guts of animals and persists forever because plastic is **(indigestible)**.
14. When plasticizers (chemicals in plastic) concentrate in fatty tissues of animals, what harmful effects can they cause? **(eggshell thinning, aberrant behavior, tissue damage)**
15. When plastic eaten by animals at low levels of the food chain shows up in animals at higher levels of the food chain, it is called **(secondary ingestion)**.

Group 6 Questions

16. When nontarget animals are accidentally caught and drowned in fishing nets, it is called an **(incidental catch)**.
17. When animals get caught and die in nets that have been lost or discarded at sea, it is called **(entanglement)**.
18. How many estimated northern fur seals die in the North Pacific each year as a result of entanglement? **(50,000)**

Group 7 Questions

19. How can six-pack rings harm animals? (**strangulation and starvation**)
20. How do sand hoppers and periwinkles use plastic? (**for temporary homes**)
21. How can using plastic litter in nests harm birds? (**chicks can become entangled and die**)

Group 8 Questions

22. What will be required to solve the plastics at sea problem? (**international cooperation**)
23. What two U.S. laws affect pollution by plastics? (**the Clean Water Act and the Ocean Dumping Act**)
24. What two international treaties address the marine pollution problem? (**the Ocean Dumping Convention and the Marine Pollution Convention**)

Group 9 Questions

25. What three characteristics make plastic so useful for man and so dangerous for sea life? (**light weight, strength, and durability**)
26. How long may plastic particles on the beach last? (**five to more than 50 years**)
27. On Amchitka Island, how many pounds of plastic litter were added to less than a mile of beach in one year? (**550 pounds**).

Group 10 Questions

28. Name one way the plastic industry can help solve the plastics at sea problem. (**manufacture degradable plastic, manufacture recyclable plastics, filter outflow from raw plastic manufacturing plants**) .
29. How can consumers reduce the amount of plastic in the sea? (**don't discard plastic trash in the ocean or on a beach**)
30. What is the first step in combating plastic pollution? (**alert industry and the public to the problem**)

The Natural Resource Shuffle

9.NR.6.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

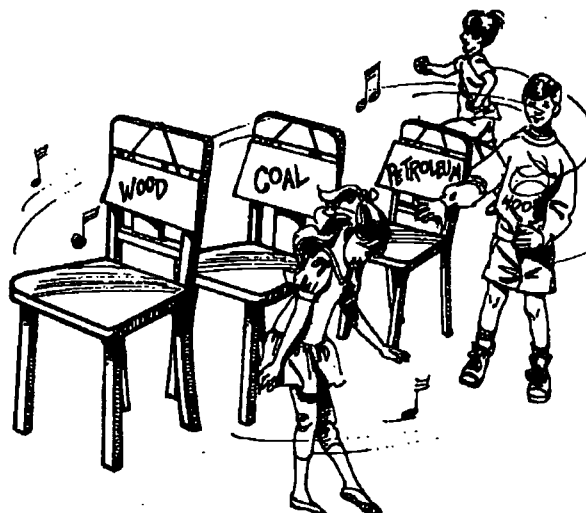
Focus: Dwindling natural resources

Subjects: Science, Language Arts, History, World Geography

Materials: Chairs equal to half the number of students, assorted objects (see list in Procedures below), index cards, markers or crayons, a world map, music and player, a bag, Resource Research handout

Teaching Time: Two class periods plus outside research time

Vocabulary: Renewable, nonrenewable, raw material, consumption, finite, natural resources



Learning Objective

Students will:

- identify natural resources in the materials we use everyday
- see how natural resources are used by the things we buy and use each day
- see where the natural resources we use come from
- identify ways we can protect natural resources.

Background

Many of our natural resources are truly **finite**, that is, they are limited in number. Competition for natural resources puts pressures on individual pocketbooks as well as national economies. Throughout history natural resources have often been the source of international conflicts.

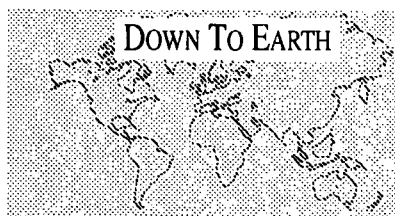
The search for gold drove much of the exploration and exploitation of the New World in the 16th and 17th centuries. It has been said that Middle East conflicts, including Desert Storm, have been fought

as much for oil and water rights as over social and religious differences.

It is important to make natural resources last. Good ways to conserve resources are to reduce **consumption** (what you buy and use), reuse what you can, and recycle as much as possible.

This activity is similar to Musical Chairs. Although based on a children's game, it can demonstrate to teenagers and adults how our resources are in limited supply.

Chairs represent natural resources and, as they are depleted, chairs are removed; however, everyone remains in the game and more people are added to simulate the growing population. The students must share chairs to demonstrate increasing stress on our diminishing supply of resources.



At the Earth Summit, leaders from many nations rallied around the environmental concept of sustainable development, that is, economic growth and environmental protection.

Source: 1994 Environmental Almanac

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Learning Procedure

Part One

1. Place enough objects in a bag for each student in the class to have one, or you may divide the class into small groups with two or three students in each group. Select a variety of items. (*soda can, aluminum foil, perfume, plastic bag, paper sack, drinking straw, comb, pencil, bottle, paper clip, ruler, etc.* *OPTION: place the names of objects such as automobile tires, compact disks, etc., on index cards and have the students choose these from the bag. In either case select items that represent a wide variety of natural resources*)

2. Have each student or group draw an object or a card and research the principal natural resource(s) that make(s) up that object. Have them answer the questions:

- What natural resources were used to manufacture the object?
- Are the natural resources renewable?
- Where are the natural resources found?
- How much of that natural resource is left worldwide?
- How much of what is left is relatively easy to obtain?
- Who (what country) uses the most of this natural resource?
- Is the consumption of this resource increasing? Why?
- What happens to the natural resource after the product has completed its useful life?
- Can the natural resource be recycled?
- What effect does recycling the natural resource have on the overall quantity and availability of the resource?
- What effect does recycling have on the manufacturing process of the product? Can the original product be made from recycled material? Does using recycled materials change the manufacturing process? Does using recycled materials use more or less energy? Does using recycled materials produce more or less pollution?

Students should be allowed enough research time to prepare a one- or two-page, fact-filled report on the resource.

Part Two

3. After several days for research, have students display the item for the class to see and deliver an oral report on their findings to the class. As students deliver their reports, use the world map to pinpoint areas where these natural resources are found.

4. After the reports have been completed, arrange chairs (chairs equal to half the number of students) to fill a large circular area representing the Earth. (*To start the game, there will be a chair for each beginning player.*)

5. Tape to each chair an index card with the name of a resource on it. See the sample cards included with this lesson. Some resources may have to be used more than once.

6. Tell the students they represent the people of the world and the chairs represent the Earth's resources.

7. Have half of the students sit in the circle of chairs. Have each student choose an item, or the name of an item, from the bag representing resources. This is the same bag used in making the research assignments.

8. Going around the circle, ask each student to name the **natural resource** and/or **raw material** used to produce it. Students should know if the resource is renewable or nonrenewable and where it can be found. (*NOTE: The students will need to have paid attention to the oral reports on resources in order to perform this task.*) Include the students sitting outside the circle in these discussions.

9. Tell students sitting in the chairs that they represent the people of today's world (the players) and the other half of the class are the future people of the world (they will sit out and watch until they are "born" and called upon to play). Give each student in both groups a crayon or marker to use later in the game.

10. Have the students in the circle stand. Play the music and have students walk around the circle, similar to Musical Chairs. While there are a finite amount of resources, there are plenty of

resources for everyone at the beginning of the game. When the music stops, everyone will find a place to sit. At this time, each player is instructed to color one of the squares on the card where he or she is sitting. This represents the consumption of part of that particular resource. **Ask:** What resource are you consuming and what is it used to make? (*Again, students who paid attention to the oral reports will have an easy time with this task.*)

11. When the music begins again, the procedure is repeated. Again, instruct the players when the music stops to find a chair (resource) and color a square representing ongoing consumption.

12. Before starting the music a third time, tell the students there are more and more people being born every day, so add three or four new members to the world's population. Begin the music. This time when the music stops, there will not be enough chairs for each to have his or her own, so those left without one must find someone who is willing to share his or her chair. Again, *each person* must color a box on that chair's card. Chairs holding two people will receive two marks on the card, chairs holding three, receive three marks and so on. Point out that this represents the escalating depletion of resources as population expands.

Everyone must be sitting before the music begins again.

13. Repeat the procedure, adding additional players with each new round. **WHEN ALL THE SQUARES ON ANY ONE CARD ARE FILLED IN, THE CHAIR IS REMOVED FROM THE EARTH.** (*This is to represent the **consumption** of that natural resource. When a resource is completely consumed and is **depleted**, ask students to imagine the world without it.*) Continue this process until nearly all the chairs are gone.

Questions for the Class

1. What would happen if the game continued and we kept populating the earth and consuming our resources?

2. Was it sometimes difficult finding someone to share a chair? Do countries have difficulty sharing resources?

3. Are some nations using resources more rapidly than others?

4. How can we preserve our natural resources? Make a list of ways to conserve our resources.

Extension Activities

1. Play the game again, but this time when a player reaches the chair, give the student the option of stating a way the resource can be recycled or conserved. If the player can think of a way to conserve (not consume) the resource, the boxes will not have to be filled. The game can go on indefinitely when the resources do not have to be consumed. Remind students that in the face of growing populations, even renewable resources need wise conservation.

2. Research and report on international conflicts over or exploration expeditions for natural resources throughout history. Note what resource was being sought and what was its ultimate use. You might want to consider Marco Polo's travels, mineral rights arguments in the Space Race to the moon, battles in North Africa during World War II, or recent international agreements not to mine resources in Antarctica.

3. At the 1992 Earth Summit, leaders signed Agenda 21, a program of sustainable development, that is, maintaining economic growth while being an active participant in protecting the environment. Have students research the implications of sustainable development.

Just Do It

Think about our natural resources when you are considering buying something. Is the item a good use of resources?

Resource Research

After you have selected an object or a card, research the principal natural resource(s) that make(s) up that object and prepare a one- or two-page, fact-filled report on the resource(s). Use the following questions to guide your research. These questions may not have an answer, depending on your selected resource. Try to find out:

- What natural resources were used to manufacture the object?
- Are the natural resources renewable?
- Where are the natural resources found?
- How much of that natural resource is left worldwide?
- How much of what is left is relatively easy to obtain?
- Who (what country) uses the most of this natural resource?
- Is the consumption of this resource increasing? Why?
- What happens to the natural resource after the product has completed its useful life?
- Can the natural resource be recycled?
- What effect does recycling the natural resource have on its overall quantity and availability?
- What effect does recycling have on the manufacturing process of the product?
- Can the original product also be made from recycled material instead of natural resources?
- Does using recycled materials change the manufacturing process?
- Does using recycled materials use more or less energy?
- Does using recycled materials produce more or less pollution?
- Does using recycled materials cost the manufacturer more or less than using the natural resource?

Bauxite (Aluminum)

Resource
used to make:
Aluminum,
Aluminum
Cans,
Automobile
Parts, etc.

Copper

Resource
used to make:
Electrical
Wiring for
homes
factories,
businesses,
cars and
computers,
etc.

Gold

Resource
used to make:
Jewelry,
Electrical
Components,
etc.

Iron in ore (steel)

Resource
used to make:
Food Cans,
Construction
Supplies,
Magnetic
Tape such as
Cassette and
Video Tapes,
etc.

Wood

Resource
used to make:
Paper, Books,
Furniture,
Construction
Materials,
etc.

Petroleum

Resource
used to make:
Gasoline,
Plastic,
Medicines,
Polyester and
Other
Fabrics, etc.

Sand				

Resource
used to make:
Glass,
Construction
Material, etc.

Cotton			

Resource
used to make:
Cotton
Fabrics such
as Denim,
Rugs, Some
Papers, etc.

Feldspar				

Resource
used to make:
Glass,
Insulation
Material, etc.

Tin		

Resource
used to make:
Metal Alloys,
Electronics,
etc.

Silver	

Resource
used to make:
Jewelry,
Electronics,
Photographic
Films, etc.

Running Out of Resources

9.NR.2.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Nonrenewable resources

Subjects: Environmental Science, Geography, Math

Materials: See list of materials itemized below

Teaching Time: Two or three class periods

Vocabulary: Raw materials, Btu, joule, renewable, nonrenewable, resource, static



MANY OF OUR NATURAL RESOURCES
ARE TRULY FINITE, THAT IS,
THEY ARE LIMITED IN NUMBER.

THERE IS WORLDWIDE COMPETITION
FOR RENEWABLE AND NONRENEWABLE
NATURAL RESOURCES.

THROUGHOUT HISTORY, NATURAL
RESOURCES HAVE BEEN THE
SOURCE OF INTERNATIONAL CONFLICTS.

Learning Objectives

Students will:

- review the raw materials used in the manufacture of products
- examine data regarding the geographic sources and life expectancies of nonrenewable resources
- describe how energy supplies can affect the manufacture of different products
- identify the United States as the prime consumer of nonrenewable resources
- describe the affects of increased consumption and population growth on depletion rates of nonrenewable resources.

Background

Resources are materials or forms of energy that can be used to make other materials. Resources can include raw materials, man-made materials, and recycled materials. **Raw materials** (like iron ore or trees) are obtained from the natural environment. Raw materials are usually the starting materials for a manufacturing process. Man-made materials (like steel or lumber) are materials or products that have been processed or altered in some way and are no longer in their natural or original state. Man-made

materials can be manufactured from raw materials or recycled materials. For example, glass bottles can be made by mixing and heating sand, soda, and lime or they can be made by melting and reforming used glass bottles.

Resources can be classified as renewable and nonrenewable. **Renewable** resources are those which can be replaced over and over again. With conservation and proper management, renewable resources such as solar energy, water, and trees can last indefinitely. **Nonrenewable** resources such as iron ore, bauxite ore, and natural gas cannot be

DOWN TO EARTH



Antarctica is rich in minerals, and while many nations want to mine there, no mining or oil exploration will be allowed in the continent for the next 50 years, as guaranteed by a treaty signed in 1991.

Source: 1993 Earth Journal

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replaced. The Earth only contains a finite or limited supply of nonrenewable resources. As a result of advances in manufacturing technology, population growth, and increasing consumer demands, the consumption of nonrenewable resources has steadily increased in the past four decades. If current trends continue, global supplies of many nonrenewable resources, including bauxite (aluminum), iron ore, lead, tin, natural gas, oil (plastics, gasoline, etc.), and uranium, will be depleted within the next century.

Strategies for extending the life expectancy of valuable nonrenewable resources include:

- using recycled materials rather than raw materials in the manufacturing process whenever possible
- substituting products made from renewable resources for products made from nonrenewable resources
- reducing consumer demand for products made from nonrenewable resources.

A less desirable strategy for extending the life expectancy of nonrenewable resources consists of developing new technologies to obtain and use supplies of resources that are currently difficult and/or expensive to acquire (such as mineral supplies in environmentally sensitive areas like Antarctica).

Consumers need to consider their personal rates of consumption and identify ways they can help stem the depletion of nonrenewable resources.

Materials

Information on making glass, paper, aluminum, and plastic from the Resource section; *Energy And Resources* work sheets (student copies); *Energy And Resources* teacher sheet

Learning Procedure

1. Review the raw materials and processes used in the manufacture of glass, paper, aluminum cans, and plastic.

2. Distribute copies of the *Energy And Resources* work sheet. Review the table in Part 1. Explain that one **Btu** (British thermal unit) is the amount of heat energy needed to raise the temperature of one pound of water one degree Fahrenheit. It is a common unit of energy used by engineers. Students may be familiar with energy measured in joules. **Joule** is the International System unit of energy equal to the work done when a current of 1 ampere is passed through a resistance of 1 ohm for 1 second. This lesson is prepared using Btu.

3. Instruct students to refer to Part 1 of the work sheet and discuss:

- Which manufacturing processes are more energy intensive?
- Which manufacturing processes are less energy intensive?
- What are the Btu requirements for manufacturing each product when recycled materials are used in place of raw materials?
- What product saves the most energy when recycled materials are used to make it?
- What product saves the least energy when recycled materials are used for manufacture?
- What happens to the energy in these products when they are thrown away? Burned? Recycled?

Have students answer questions one and two on the work sheet.

4. Define the term "resource." Review the difference between a renewable resource and a nonrenewable resource, and provide examples of each. Ask:

- What clothing materials come from renewable resources? Nonrenewable resources?
- What packaging materials come from renewable resources? Nonrenewable?

Review the table in Part 2 of the work sheet. Explain that the resources used to manufacture many products are nonrenewable, in limited supply, and not found in the U.S. Conduct a discussion:

- What is **static** use? (*Use that stays at the same level.*)
- Why are projected rates of use greater than static rates of use?
- Is the actual use of these materials static or increasing at the projected rates?
- What influence does an increase in human population have on the rate of use of resources?
- What resources are not found in the United States?
- What country or area has the greatest overall reserves of these resources?
- What is the U.S.'s present relationship with some of the countries that contain these resources?
- Why is dependence on other countries for resources a problem at times?
- How can we as individuals help stem the depletion of nonrenewable resources?

List these ideas on the board. Have students answer questions three and four on the work sheet.

5. Tell students that our earth is so rich in resources that some people say there actually may be plenty of resources available ... for a price. But it may take more energy, equipment, and environmental degradation to get these less-easily obtained resources out of the earth. Ask students to identify the pros and cons of locating and acquiring less obtainable resources.

For example: geologists report that it could be just 20 to 40 years before the known reserves of easy-to-pump petroleum are spent. While there may be vast un-tapped reserves in the arctic regions and the former Soviet Union, global treaties and political differences may prohibit access to these resources. When the easily accessible resources begin to run out, we will have to turn to oil from shale and off-shore wells.

Extension Activities

1. Have students investigate the potential of mining minerals beneath the oceans. Who "owns" these minerals?
2. Substitution is one way of replacing materials that are in short supply. Ask students to identify what qualities materials would need to be able to substitute for aluminum, iron, lead, plastic (petroleum), and tin.
3. Have students investigate mining in South Carolina. Why is mining a controversial environmental issue?
4. Have the class create a world map of resources with flags on pins to represent resources and an estimate of the remaining reserves.
5. As a homework assignment have students review the handout – *Selected Nonrenewable Natural Resources: Life Expectancies & Prime Consumers* – and answer the questions on the handout, *Nonrenewable Resources*.

Just Do It

Have students inform family members and classmates of ways individuals can help conserve nonrenewable resources.



ENERGY AND RESOURCES

Part 1

Energy requirements
using raw materials
for manufacture:

Energy savings
using recycled materials
for manufacture:

Paper 20,373 Btu/lb
Glass 7,611 Btu/lb
Steel 14,778 Btu/lb
Aluminum 98,560 Btu/lb
Plastic 18,532 Btu/lb

Paper 30-55% (of the energy
Glass 8-32% required for
Steel 47-74% manufacture using
Aluminum 95% raw materials)
Plastic 60-70%

1. Which industries will be hard hit in the next energy crisis? Why? _____

2. In what two ways would the plastics industry be affected if oil prices rose sharply? _____

Part 2

NONRENEWABLE NATURAL RESOURCES

Life Expectancies and Prime Consumers

Resource	Reserve Base	Countries or Areas with Highest Reserves	Prime Consumers	Life Expectancy in Years	
				Static Use at current level	Use growing at projected rates
Aluminum in Bauxite	23.2 billion metric tons metric ton = 2,200 lbs.	Guinea 25% Australia 20% Brazil 13% Jamaica 9%	USA 42% Russia 12%	312 years	63 years
Iron in Ore	98 billion short tons short ton = 2,000 lbs.	Russia 26% Australia 21% Brazil 11% Canada 10% S.Africa 7% USA 6%	USA 28% Russia 24% Germany 7%	172 years	62 years
Lead	142 million metric tons	Australia 20% USA 12% Canada 10%	USA 25% Russia 13% Germany 11%	37 years	25 years
Tin	4.2 million metric tons	Malaysia 26% Indonesia 16% Brazil 15% China 9%	USA 24% Japan 14%	41 years	31 years

3. List the prime consumer of each resource. Aluminum: _____ Iron Ore: _____
Lead: _____ Tin: _____

If consumption grows at projected rates, which resource will be the first to be depleted? Next? List in order. Next to these, list how old you will be when the resource is depleted.

1. _____ 2. _____ 3. _____ 4. _____

ENERGY AND RESOURCES

Part 1

Energy requirements
using raw materials
for manufacture:

Paper	20,373 Btu/lb
Glass	7,611 Btu/lb
Steel	14,778 Btu/lb
Aluminum	98,560 Btu/lb
Plastic	18,532 Btu/lb

Energy savings
using recycled materials
for manufacture:

Paper	30-55%
Glass	8-32%
Steel	47-74%
Aluminum	95%
Plastic	60-70%

1. Which industries will be hard hit in the next energy crisis? Why?

All industries, especially aluminum; it takes a lot of energy to manufacture aluminum from raw materials.

2. In what two ways would the plastics industry be affected if oil prices rose sharply?

1. Plastics are made from petroleum; 2. It takes energy to make plastics.

Part 2

NONRENEWABLE NATURAL RESOURCES

Life Expectancies and Prime Consumers

Resource	Reserve Base	Countries or Areas with Highest Reserves	Prime Consumers	Life Expectancy in Years	
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Tin	4.2 million metric tons	Malaysia 26% Indonesia 16% Brazil 15% China 9%	USA 24% Japan 14%	41 years	31 years

3. List the prime consumer of each resource. Aluminum: USA Iron Ore: USA
Lead: USA Tin: USA

If consumption grows at projected rates, which resource will be the first to be depleted? Next? List in order. Next to these, list how old you will be when the resource is depleted.

1. Lead 2. Tin 3. Iron 4. Aluminum

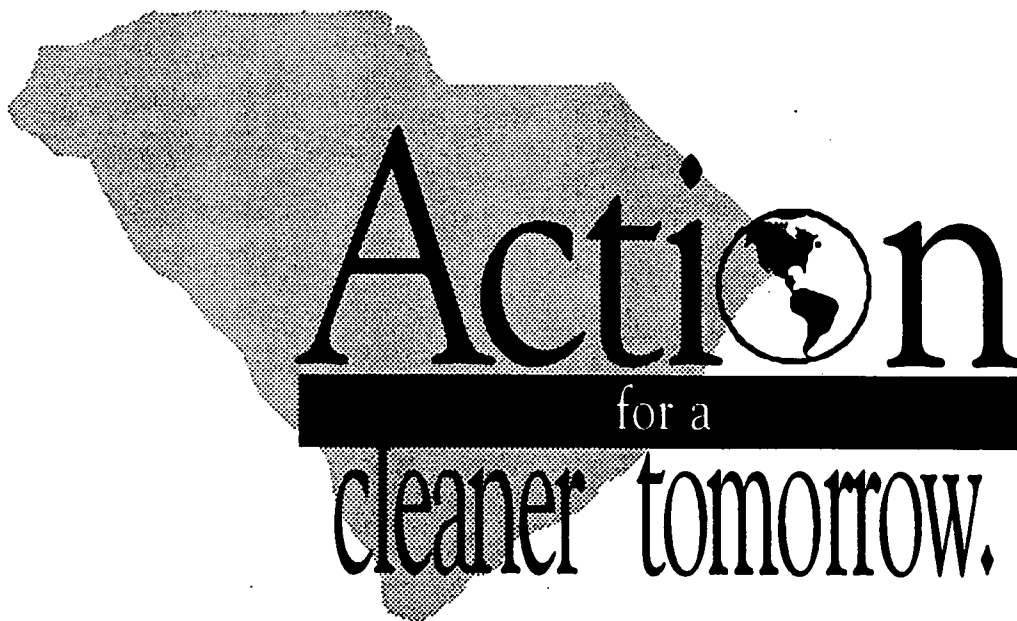
NONRENEWABLE RESOURCES

Examine the chart *Selected Nonrenewable Natural Resources: Their Life Expectancy and Prime Consumers*. Then answer the following questions:

1. Which column under the heading "Life Expectancy in Years" do you think is more accurate in estimating the length of time our nonrenewable natural resources will last?
2. What are some factors leading to the accelerated use of resources?
3. Examine the "static use" column under the heading "Life Expectancy in Years." Which nonrenewable natural resource will be depleted (used up) first?
4. Which countries have the highest reserves of the resource? Locate these countries on a world map.
5. Why does the U.S. need to be concerned with the depletion of this resource?
6. According to the static index, which nonrenewable resource will last the longest?
7. According to the projected rates index, which nonrenewable resource will last the longest?
8. Which countries have the highest reserves of this resource?
9. With which countries will the U.S. need to cooperate in order to get the amount of this resource it needs?
10. List the resources that will probably be depleted within the next 40 years given projected use rates.
11. What role do recycling and careful use play in extending the availability of these resources?

SELECTED NONRENEWABLE NATURAL RESOURCES: LIFE EXPECTANCIES & PRIME CONSUMERS

Resource	Reserve Base	Countries or Areas with Highest Reserves	Prime Consumers	Life Expectancy in Years		Percentage Recycled (U.S.)
				Static Use at current level	Use growing at projected rates	
Aluminum in Bauxite	23.2 billion metric tons metric ton = 2,200 lbs.	Guinea 25% Australia 20% Brazil 13% Jamaica 9%	USA 42% Russia 12%	312 years	63 years	Aluminum 25%
Iron in Ore	98 billion short tons short ton = 2,000 lbs.	Russia 26% Australia 21% Brazil 11% Canada 10% S.Africa 7% USA 6%	USA 28% Russia 24% Germany 7%	172 years	62 years	Iron & Steel 23%
Lead	142 million metric tons	Australia 20% USA 12% Canada 10%	USA 25% Russia 13% Germany 11%	37 years	25 years	49%
Tin	4.2 million metric tons	Malaysia 26% Indonesia 16% Brazil 15% China 9%	USA 24% Japan 14%	41 years	31 years	
Copper	525 million metric tons	Chile 21% USA 16% Russia 10% Zambia 6%	USA 33% Russia 13% Japan 11%	63 years	36 years	42%
Gold	1,450 million troy ounces	So. Africa 53% Former Eastern Bloc Countries 20% USA 8%				35% Refinery production from scrap
Silver	10.8 billion troy ounces	USA 21% Canada 13% Mexico 13%	USA 26% Germany 11%	20 years	17 years	23% Refinery production from scrap
Chromium	7.5 billion short tons	So. Africa 83% Zimbabwe 11%				
Platinum	1.2 billion troy ounces	So. Africa 90% Russia 10%				



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Curbing Our Resource Appetite

9.NR.3.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 11 – 12

Focus: Curbing consumption of natural resources

Subject: Math

Materials: Calculators that have exponential functions, *Resource Consumption* work sheet (student, teacher), graph paper (or the included graphing sheet)

Teaching Time: One to two class periods

Vocabulary: Limited supply, finite, exponential function, consumption, throwaway society, planned obsolescence



Learning Objectives

Students will:

- predict the different amounts of a natural resource that will be consumed if consumption increases at different rates
- graph predictions of natural resource consumption as a function of time
- describe the effects, benefits, and costs of different resource consumption rates
- identify ways to reduce the consumption rates of natural resources.

Students use calculations and graphs to predict and analyze the effects of concepts or practices such as “planned obsolescence” and a “throwaway society” on the consumption of finite natural resources.

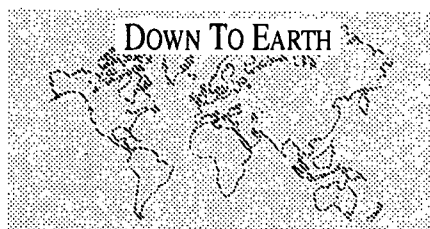
Background

When comparing living standards worldwide, the average American is considered wealthy. Our lifestyle has led to us being labeled a “**throwaway society**.” We are used to consuming as much as we want. Americans can generally afford to dispose of old items whenever we want new ones without considering the consequences of our actions.

Every year, more and more manufacturers market products that are designed to be used once or for a short time and then thrown away. The **planned obsolescence** built into products such as disposable razors, disposable diapers, disposable lighters, and disposable batteries further compounds the problems created by our throwaway society.

The consequences of our actions are many: pollution of our air and water, depletion of the soil, and destruction of the habitats of other organisms with whom we share the planet. As our population grows, so do the problems we create. Our growing population and our lifestyle based on high rates of **consumption** are seriously threatening global supplies of many natural resources.

Economists contend that as a particular resource becomes scarce, and consequently more costly, society may switch to a substitute. This concept is true provided new technologies are developed to supply suitable substitutes. However, if society finds new, low-cost ways of obtaining the resource, or economic growth is such that the population can



It could be 20 to 40 years before the easy-to-pump petroleum is spent. And by the year 2030 the United States will be importing 80 percent of its oil.

Source: *Garbage* magazine. Nov/Dec 1991

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afford the rise in cost of the resource, it may continue to be used.

For example, oil is a nonrenewable or **finite** resource. In order to have oil in the future, the United States must discover new reserves, develop new technologies to use sources too costly to drill for now, or seek other energy alternatives. How long will it be before we are forced to choose an alternative? It is possible to predict mathematically the amount (**A**) of a resource that will be consumed in the future based on data regarding consumption's rate of increase in the past. To do this, we must know the rate (**r**) of increase in consumption of the resource per year and the number (**n**) of years over which the consumption takes place.

If the amount of consumption grows at a rate of **r** (percentage per year) from some initial value (**A₀**)

- after one year, $A_1 = A_0 (1 + r)$
- after the second year, $A_2 = A_0 (1 + r)^2$
- after **n** years, $A_n = A_0 (1 + r)^n$.

This is called an **exponential function** and has the form $y = ab^x$, where **b** is an element of the set of real numbers (only positive) and **x** is an element of the set of real numbers. This exponential function is continuous and increasing if **b** is greater than 1, but decreasing if **b** is less than 1.

Learning Procedure

1. Ask students what they think happens to the population of a specific wild animal (such as deer) when: (1) they eat only one type of plant, (2) the number of animals increases, and (3) there is no increase in the number of available plants. Help students discover that the plant used as food for the animals is a resource of **limited supply**. Help them understand that the population can grow exponentially, but as the food supply decreases in availability, the population will drop off exponentially.

2. Define the terms “throwaway society” and “planned obsolescence.” Ask students how the throwaway philosophy could affect natural resources of limited supply. Provide examples of

finite natural resources (resources of limited supply) such as coal, oil, natural gas, aluminum, iron ore, copper, tin, and uranium.

3. Discuss the equation used to predict the consumption (rate of use) of natural resources as a function of time.

$[A_n = A_0 (1 + r)^n]$ where **A₀** = amount of resource used initially, **r** = rate of increase in consumption per year, **n** = number of years of consumption, and **A_n** = amount of resource used after **n** years of consumption.]

Be sure to explain what is meant by the term “**exponential function**” and review an example if necessary.

4. Distribute the *Resource Consumption* work sheets, calculators, and graph paper. Explain that the population of the United States is currently increasing at a rate of approximately 2 percent per year. Refer to Part 1 of the work sheet and explain that the calculations in Table 1 were computed assuming that the consumption of natural resources increases at approximately the same rate as population. Instruct students to complete the missing calculations in Part 1 and record their figures in Table 1. (*Students may work in small groups if a limited number of calculators is available.*) When students are finished with their calculations, explain that in order to determine the total amount of a resource consumed over the 80-year-period, all of the values in a given column of Table 1 would have to be added together.

5. Refer to Part 2 of the work sheet. Instruct students to complete Part 2 and record their calculations in Table 2.

6. Discuss the results. Ask students to compare the differences in the amount of resources consumed during years 10, 40, 70, 100, 140, and 160 for the four different consumption rates. Ask students to explain what effect a greater rate of increase in consumption has on the amount of resources consumed over extended time periods. Have students calculate how many units of the natural

resource in Part 2 could be saved over the first 100 year period by reducing the rate of increase in consumption from 2 percent per year to 0.9 percent per year. Remind students to sum the values for years 10 through 100 first.

7. Refer to Part 3 of the work sheet. Have students complete Part 3 using the graph paper. All four consumption curves should be plotted on the same graph. Ask students to describe and compare the similarities and differences between the four graphs.

8. Discuss the possible impacts on our society if:
(a) there is a finite supply of natural resources and
(b) consumption growth continues at the present rate of 2 percent per year. Ask students the following questions:

- If the consumption curve of a natural resource approaches an asymptote, what would this mean? (*An asymptote is a line considered a limit to a curve in the sense that the perpendicular distance from a moving point on a curve to the line approaches zero as the point moves an infinite distance from the origin.*)

- Since this condition is likely for some resources, what are some factors that could slow the depletion rate of our natural resources? (*List students' answers on the board.*)

- How can a zero growth rate in resource consumption be accomplished? (*List students' answers on the board.*)

9. Have students list the benefits of reducing the rate of resource consumption and the problems that a reduction would cause. Compare the list of benefits against the list of problems. **Ask:** What do you think is the most important factor we should consider in the extraction and use of natural resources? Why? (*List students' answers on the board.*)

Collect completed work sheets and graphs and compare student answers with those on the teacher sheet.

Questions for the Class

1. What are some probable future effects of the increasing rate of consumption of natural resources?
2. What are the benefits of reducing our resource consumption rate?
3. As a consumption curve approaches the asymptote, what probably happens to the cost of the resource?
4. Have students list four ways to reduce the consumption rates of natural resources.

Extension Activities

1. Ask students to list some items that are so inexpensive to buy, compared to the cost of repairing them, that it is cheaper to replace them. (*Some examples are pocket calculators, some watches, telephones, socks, radios, and clocks.*)

How could these items be reused, recycled, or exchanged?

How could they be produced in such a way that their lives could be extended?

2. Have students consider a world with all petroleum resources depleted. What would your life be like? Have students write their responses in a story format, describing a typical day without products made from petroleum.

3. Ask students to explore the medical, social, or political impacts of reducing the rate of consumption of a particular resource, such as petroleum or bauxite.

Just Do It

Identify two finite natural resources you consume and develop a plan for reducing your rate of personal consumption of these resources.

RESOURCE CONSUMPTION

Part 1

Use the equation $A_n = A_0 (1 + r)^n$ to calculate the 8 missing values in Table 1 below.

$$A_0 = 100,000 \text{ units}$$

$$r = .02 \text{ (2 percent per year)} \quad n = \text{number of years (3, 10, 18, 29, 40, 51, 62, 73)}$$

Use the “y^x” key on your calculator to compute $(1 + r)^n$.

Table 1

Year #	Amount	Year #	Amount	Year #	Amount
1	102000.000	28	174102.424	55	297173.077
2	104040.000	29		56	303116.539
3		30	181136.162	57	309178.870
4	108243.216	31	184758.885	58	315362.447
5	110408.081	32	188454.063	59	321669.696
6	112616.242	33	192223.144	60	328103.09
7	114868.567	34	196067.607	61	334665.152
8	117165.939	35	199988.959	62	
9	119509.258	36	203988.739	63	348185.625
10		37	208068.514	64	355149.338
11	124337.432	38	212229.884	65	362252.325
12	126824.180	39	216474.482	68	369497.371
13	129360.664	40		67	376887.319
14	131947.877	41	225220.051	68	384425.066
15	134586.835	42	229724.452	69	392113.567
16	137278.572	43	234318.941	70	399955.839
17	140024.143	44	239005.320	71	407954.956
18		45	243785.427	72	416114.055
19	145681.119	46	248661.136	73	
20	148594.741	47	253634.359	74	432925.063
21	151566.636	48	258707.046	75	441583.565
22	154597.969	49	263881.187	76	450415.237
23	157689.929	50	269158.811	77	459423.542
24	160843.727	51		78	468612.013
25	164060.602	52	280032.827	79	477984.253
26	167341.814	53	285633.484	80	487543.939
27	170688.650	54	291346.154		

RESOURCE CONSUMPTION

Part I

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$$r = .02 \text{ (2 percent per year)} \quad n = \text{number of years (3, 10, 18, 29, 40, 51, 62, 73)}$$

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15	134586.835	42	229724.452	69	392113.567
16	137278.572	43	234318.941	70	399955.839
17	140024.143	44	239005.320	71	407954.956
18	[142824.626]	45	243785.427	72	416114.055
19	145681.119	46	248661.136	73	[424436.337]
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26	167341.814	53	285633.484	80	487543.939
27	170688.650	54	291346.154		

Part 2

Use the equation $A_n = A_0 (1 + r)^n$ to calculate the amount of resource consumed over a 160 year period with four different resource consumption rates: 0.9 percent, 1.0 percent, 2.0 percent, and 3.0 percent.

Calculate and record the values in 10 year increments in Table 2 below.

($A_0 = 1,000,000$ units of a natural resource used initially)

Table 2

AN EXPONENTIAL FUNCTION: NATURAL RESOURCE CONSUMPTION

Rate of increase in consumption per year: 0.9% 1.0% 2.0% 3.0%

YEAR #	$r = .009$	$r = .01$	$r = .02$	$r = .03$
10	1,093,733	1,104,622	1,218,994	1,343,916
20				
30				
40				
50				
60				
70				
80				
90				
100				
110				
120				
130				
140				
150				
160				

Part 3

Use the data in Table 2 to construct a graph illustrating natural resource consumption as a function of time for the four different consumption rates. For each consumption rate, only plot consumption values between 1 and 9 million. Label your best fit lines for each consumption rate graph.

Part 2

Use the equation $A_n = A_0 (1 + r)^n$ to calculate the amount of resource consumed over a 160 year period with four different resource consumption rates: 0.9 percent, 1.0 percent, 2.0 percent, and 3.0 percent.

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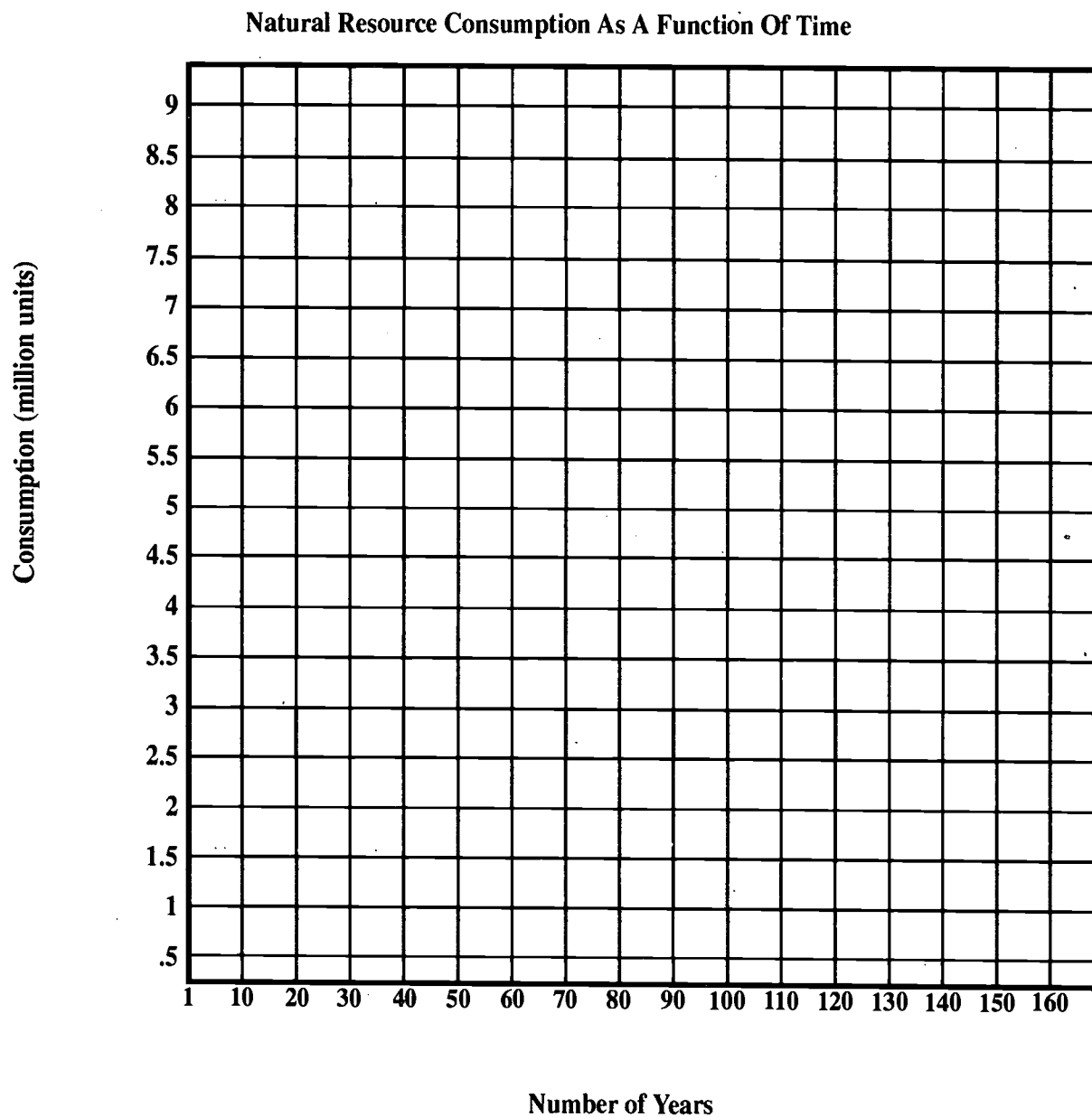
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YEAR #	r = .009	r = .01	r = .02	r = .03
10	1,093,733	1,104,622	1,218,994	1,343,916
20	1,196,253	1,220,190	1,485,947	1,806,112
30	1,308,383	1,347,489	1,811,361	2,427,262
40	1,431,023	1,488,863	2,208,039	3,262,037
50	1,565,158	1,644,632	2,691,588	4,383,906
60	1,711,866	1,816,697	3,281,030	5,891,603
70	1,872,326	2,006,763	3,999,558	7,917,821
80	2,047,827	2,216,715	4,875,439	10,640,891
90	2,239,778	2,448,632	5,943,133	14,300,467
100	2,449,721	2,704,813	7,244,646	19,218,631
110	2,679,342	2,987,792	8,831,183	25,828,234
120	2,930,488	3,300,386	10,765,163	34,710,987
130	3,205,174	3,645,680	13,122,674	46,648,664
140	3,505,607	4,027,099	15,996,465	62,691,903
150	3,834,201	4,448,423	19,499,602	84,252,676
160	4,193,596	4,913,826	23,769,906	113,228,551

Part 3

Use the data in Table 2 to construct a graph illustrating natural resource consumption as a function of time for the four different consumption rates. For each consumption rate, only plot consumption values between 1 and 9 million. Label your best fit lines for each consumption rate graph.



Deinking Paper

9.RE.8.F

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 9 – 12

Focus: Paper recycling and how the technology of deinking paper is changing recycling

Subject: Science

Materials: *Recycled Paper and Its By-Products* handout included with this lesson, materials for papermaking listed below

Teaching Time: Several class periods

Vocabulary: Deinking, flotation deinking, pulp, slurry

Materials

This lesson includes a papermaking exercise. The materials needed include:

- several sheets (at least 9" x 12") of different types of waste paper (newsprint, used white office paper, etc.)
- nylon stocking, cheese cloth, or millipore filter
- blender and wide-mouthed container to hold water (a pitcher will do)
- pans
- large mixing spoons
- cups for scooping
- blotters
- large dowels or rolling pins
- dishwashing detergent
- sponges or old towels to soak up water
- warm water
- a place to dry paper overnight
- iron (to help dry paper).

Learning Objective

Students will:

- recycle paper to see the by-products of the process
- understand that by-products of all manufacturing processes pose potential environmental concerns
- see how technology is changing paper recycling.

In this activity, students actually make recycled paper and investigate the process of removing ink from paper during recycling.

Did You Know...

Making paper from recycled materials results in 74 percent less air pollution and 35 percent less water pollution.

Each ton of recycled paper requires approximately 4,100 kilowatthours less energy as paper made from virgin materials.

Background

Paper cannot be recycled indefinitely because the fibers break down eventually. However many grades of paper can be deinked, cleaned, and bleached, processes that allow paper to be recycled into newsprint or used to make gameboards, tissue paper, ticket stubs, packaging, covers for books, insulation, and animal bedding.

Although recycling paper saves natural resources and energy, pollution problems still exist. To be recycled into more paper, waste paper must have contaminants removed.

Black printing inks used in newspapers are composed of about 30 percent pigment (usually carbon black) and about 70 percent petroleum-

DOWN TO EARTH



In one year, the American Telephone & Telegraph Company saved \$1 million in disposal costs and made a \$365,000 profit by recycling its office waste paper.

Source: *The Green Consumer*

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refined oil. Colored pigments in magazines – and many in newspapers – contain heavy metals. The papermaking process requires large amounts of water, all of which must be cleaned of contaminants after it is used. The remaining paper sludge also must be disposed of properly because petroleum distillates and heavy metals can remain present in this material. Both the contaminated water and sludge must be treated in a wastewater treatment plant before being released into the environment.

The S.C. Recycling Markets Guide lists 38 companies that are involved in paper recycling in this state, ranging from manufacturers such as Carotell Paper Board Corporation in Taylors, S.C., to dealers located across the state such as Paper Stock Dealers, that collect and bale cardboard and paper from grocery stores and most large retailers. Carotell only makes paper from waste paper (5,000 to 6,500 tons per month) and reprocesses it to make recycled paperboard products. Paper Stock Dealers currently collects about 200 tons per day from area businesses and bales it for shipment to area mills.

Whether collecting and baling or reprocessing, businesses must be able to make a profit from recycling to stay in business.

Many paper dealers pay small amounts for high quality waste paper if it is delivered to their site.

It costs from \$18 to \$22 per ton to bale waste paper that may only bring \$25 to \$30 per ton from the mill. With labor and transportation costs to consider, waste paper has very narrow margins for making a profit.

Many of the companies collecting and recycling paper in South Carolina are using it to make paper board. When waste paper is made into paper board it does not have to be **deinked**, that is, it does not have to have the ink removed.

For paper to be made into high grade white paper it must have the ink removed. This deinking requires special technology. Currently no deinking facilities exist in South Carolina.

Learning Procedure

1. Review with the class the background provided with this lesson and the Resource section on paper.
2. Explain to students that they are going to make recycled paper from a variety of waste paper. (*Note: If class size or resources are not adequate to have groups of students make paper, perform the papermaking portion of the lesson as a demonstration with students participating.*)
3. Have students read the article, *The Emerging World of Deinking*, included with this lesson. Discuss how technology will continue to improve and change the processes of recycling.

Question for the Class

What kinds of paper can be recycled in your area?

Making Recycled Paper

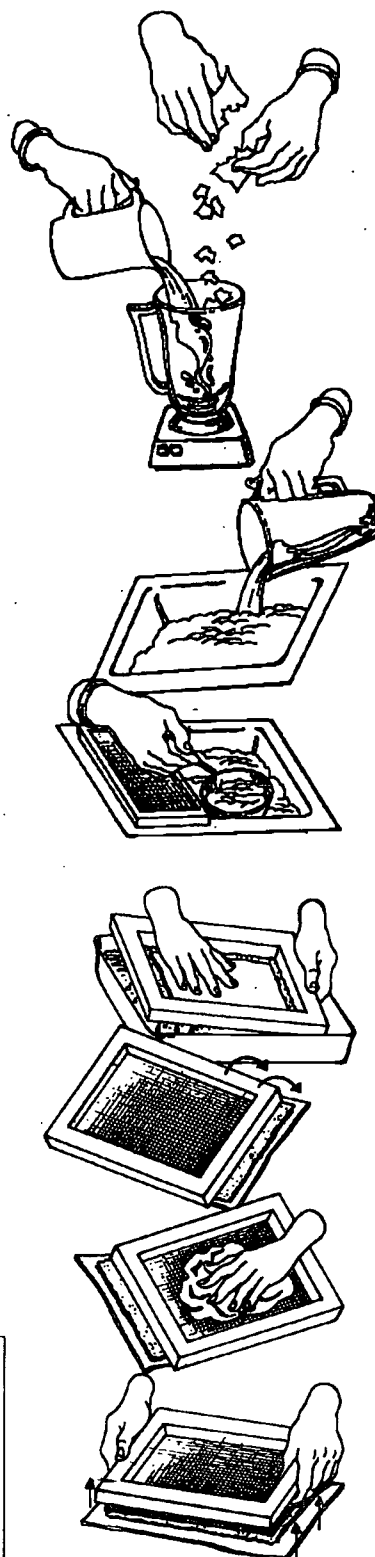
1. Divide the class into small groups and have each group make recycled paper out of a different type of waste paper.
2. While making paper, students should collect the water that drains through the screen while the paper is being pressed and check it for pollutants by testing the pH and noting the color and sediment. Have each group strain the collected water and sludge through a filter and examine what contaminants remain.
3. Have students use the collected water after straining and note its pH, color and sediment. Set samples aside (do not disturb) and repeat pH, color and sediment tests and observations after 24 hours.
4. Have each group complete the *Recycled Paper and Its By-Products* questions and discuss the results as a class.

Extension Activity

Visit or write a South Carolina pulp mill. Find out if the mill uses only virgin timber, a mixture of virgin timber and waste paper, or only waste paper. Research the air and water pollution control methods used in papermaking plants.

Making Paper

1. Tear sheets of used paper (one different type of paper for each group) into small strips about one-inch square. Loosely pack into blender until $\frac{1}{3}$ to $\frac{1}{2}$ full. Add warm water until blender is $\frac{2}{3}$ full.
2. Blend, with lid on, until the paper looks like oatmeal mush (5 to 10 seconds).
3. Pour the mush into a pan. When pulp is mush consistency, add about $\frac{1}{2}$ inch (1.27 cm) of water for every blender of pulp, adding more or less depending upon the thickness of paper desired.
4. Scoop the pulp mixture evenly onto the screen with a cup (hold the frame over half the pan). Let the pulp drain.
5. Place a piece of blotter over the wet pulp paper formed on the screen, then flip the screen over so the pulp paper is between the blotter and the screen with the screen on top.
6. Soak up extra water with a sponge. This water can be squeezed out and collected along with the water in the pan. Use a large dowel or a rolling pin.
7. Lift off the screen and place the new paper in a safe place to dry. Drying takes one or two days. Exchange blotter and dry paper towels every few hours if you want the paper to dry more quickly; or you may iron the paper to speed the process. If you choose to iron your paper, place a sheet of paper between the new paper and the iron.



Recycled Paper and Its Byproducts

Discuss with the class:

1. What materials are in the sediment and sludge?
2. What is causing the discoloration of the water?
3. Is the strained water less polluted than the unstrained water? Why?
4. Should the remaining paper sludge be treated as solid waste or hazardous waste?
5. How can we reduce pollution from potential byproducts?

Note: Answers will vary between the classroom experiment and a commercial paper recycler. While the basics of paper recycling are the same, chemicals, materials, and the equipment are different.

The Emerging World of Deinking

excerpts from the article that appeared in Waste Age, June 1992

Whether by floating, washing, or exploding, the technology to remove ink from waste paper is flourishing in the U.S.

As more and more waste paper is collected by U.S. recycling programs, paper mills are having a hard time keeping pace. Despite many commitments across the country to recycle paper with new deinking facilities, the demand for waste paper has been unable to keep up with supply. That's one of the main reasons prices for waste paper are dismal.

Mills do have the technology to handle the waste paper. Complete deinking technologies have developed at a rapid pace in recent years, and the paper industry promises 9.3 million tons of [annual] deinking capacity in North America by 1995. Processing that capacity will require some form of the two most common deinking technologies at the heart of it all: flotation and washing. Steam explosion technology and other methods for deinking are gaining momentum – with many pilot programs proving successful – but they have yet to be used in large-scale commercial production of deinked pulp.

Flotation deinking is self-describing. Ink is literally floated off paper and out of a pulp slurry.

An extensive series of steps

Bowater, a major newsprint producer in the southern U.S., brought a flotation deinking machine on-line in Calhoun, Tenn., last year [1991]. The \$67 million facility uses about eight broad steps to deink 380 tons per day of old newspapers (ONP) and old magazines (OMG) to produce 300 tons per day of clean secondary fiber.

Mills recently began mixing in OMG because they found the clay content helps in the flotation stage.

Magazine paper uses clay to help smooth the paper surface and create an optimum surface to which glossy inks can adhere. Mills that use flotation but include no OMG add clay or other fillers directly. The most common mixture of ONP and OMG is a 70/30 percent mix, although some mills vary the percentages based on what they want to accomplish.

Clean ONP and OMG ride a conveyor to a drum pulper or a hydropulper. Bowater's pulper, throws a slushball of ONP, OMG, and water around for about 20 minutes. This action serves to break apart the paper by slowly deteriorating all the bonds holding the paper together.

The unique rotating ability of the drum not only ensures a good tossing, but after time works the paper to one end, where tiny slots wait to begin the first of many filtration steps. Pulp and water drain through these one-millimeter holes, leaving behind large undesirables such as plastics, wire, labels, and "stickies." Stickies are any adhesive-type substance found on waste paper, and they can be a big contaminant in any recycled paper-making process.

Smaller undesirables face more screens, as the pulp mass moves toward the flotation cells. These holes, six-one-thousandths of an inch in width, stop plastics and other debris that made it out of the drum pulper, as well as capture some larger ink particles. As the pulp moves on toward the flotation cells, only ink remains as the last major undesirable targeted for elimination.

Capturing ink in the cell

The barrage on the ink starts 10 feet before the flotation cell, where a section of wide pipe called a static mixer injects air bubbles into the pulp slurry as it moves toward the cell. Full of air and water, the pulp is ready to be dumped into a long flotation cell. Bowater's cell is 10 feet wide by 40 feet long. There, the forward movement is stopped and the mass of pulp nearly comes to rest. As it sits there, the bubbles of air slowly rise to the surface, capturing particles of ink along the way and dragging them to the surface of the mush.

Ink particles hitch rides with the air bubbles because of chemistry. "Air bubbles are hydrophobic, which means they don't like water," explains Tom Woodward, marketing manager of Betz PaperChem (Jacksonville, Fla.). "Hydrophobic things attract other hydrophobic things. Most ink particles are naturally hydrophobic." Clay particles coming off the OMG fibers also help to absorb more ink.

Once on the surface of the slurry, the ink and ink-soaked clay is skimmed off the top and the slurry moves to another stage. At Bowater, the slurry is put through five flotation cells, where ink is continually removed in this manner. In the last cell, the pH level of the water is changed from alkaline to acidic. This final pH shock helps loosen even more ink, says Sam Bittes, assistant project manager of engineering for the Calhoun mill. After flotation cells have thoroughly worked the paper, centrifugal cleaners spin the pulp mass. Denser particles, including larger ink particles, are flung to the outside of the vessel and removed.

Finally, the pulp is cleaned across fabric washers. These are actually fine sheets of 60-mesh fabric, meaning they have 60 holes per square inch. This washing stage is somewhat similar to systems that use strictly washing to deink their pulp. The principle is the same in that water is drained from the pulp and more ink is cleaned off, leaving almost 100 percent pulp.

The deinked pulp at Bowater is then dried and used as feedstock for the production of newsprint at the Calhoun mill. Bowater removes 98-99 percent of the ink or "all visible ink," according to Bittes. The mill adds virgin fiber to produce 2,250 tons per day of newsprint containing up to 40 percent recycled content; on the average, sheets have 15-20 percent recycled content.

Approximately 800 newspapers use Bowater's recycled newsprint, including *USA Today* and the *Washington Post*.

Like laundry in a blender

Strictly washing systems use essentially the same types of initial screens and cleaners as the flotation system described, but the core of the line is large washing vessels, or "giant kitchen blenders," according to Southeast Paper Manufacturing (Dublin, Ga.). Southeast Paper's washing system deinks about 560,000 tons per year of ONP to produce 100 percent recycled-content newsprint.

Southeast's process starts by mixing ONP with 20,000 gallons of water and special chemicals that help pull the ink off the paper. This recipe is mixed inside continuous pulpers, which are 20 feet in diameter and churn the mass with six-foot rotors. "The process lifts ink from paper just like detergents lift grease and dirt from clothes in a washing machine," the company explains.

What happens next is actually the opposite of what happens in the flotation process. Many of the chemicals in the pulpers change ink particles, which naturally don't like water, into hydrophilic particles that do like water. As a result, these particles drain off with the water and the pulp is left behind, says Betz PaperChem's Woodward.

"It's just like doing a load of laundry over and over again—a series of dilutions and thickenings. You rinse it off and hope it doesn't get back on the clothes—or the pulp," Woodward notes. Much of the chemicals used in the process are called anti-redeposition agents, just like laundry detergents. In fact, Woodward says when he first entered the field of deinking, much of the background information he perused came from the laundry detergent industry. Once completely cleaned, the pulp is bleached with peroxide; this adds brightness to the recycled paper. Using this process, Southeast produces 460,000 tons per day of recycled content newsprint for a number of customers, including the *New York Times*.

Which is best?

Flotation deinking came to the U.S. about five years ago from European and Asian sources. Japan, Germany, Finland, and Sweden had been using

flotation deinking for years, because they needed to conserve as much water as possible given their limited resources. Since flotation requires less water than washing, it was the system of choice for these countries. In the U.S., meanwhile, washing systems were traditionally the only way paper was deinked. In the past five years things have changed dramatically.

"Washing is relatively expensive compared to flotation," Bowater's Bittes says. "It [washing] was the way it was done since whenever deinking began years ago until about five years ago. It's the older, conventional way of doing it...[and] it uses huge amounts of water." Bowater saves water by primarily using the flotation process.

According to Betz PaperChem's Woodward, the answer to which process deinks better may be both technologies. "If there is a trend in newsprint deinking," Woodward says, "it's a combination approach of washing and flotation deinking, although flotation is often referred to as the workhorse of the two."

Justification for a combination of the two systems makes sense based on newsprint or office paper deinking, because mills want to lift as much ink as possible in the quest for brighter recycled sheets. Ink particles come in a wide range of sizes from one to 350 microns or more in diameter. Each system has its limitations in catching different sizes, but working in tandem, the processes can remove more ink.

Washing works best for the smallest sizes in the one-to 20-micron range, while flotation is most efficient in the 20 to- 150-micron range, Woodward says. Although the smallest dot of ink visible to the human eye falls around the 60 micron diameter, particles below that can still dull brightness by absorbing rather than reflecting light. Such dullness can be picked up by the human eye. At this point, the choice of which system to use – or which system to use the most of in combination – depends on what a mill wants to produce and what a mill is using as feedstock.

New technologies, tougher inks

With more new types of waste paper being collected for recycling, a need for alternate methods of deinking has arisen in the paper industry. Steam explosion deinking, for example, is slowly gaining speed and acceptance in the paper industry as a viable alternative to flotation or washing. Developed by Stake Technologies Ltd. (StakeTech, Norval, Ont.), the process literally explodes waste paper into pieces.

In explosion technology, waste paper is fed into a high pressure chamber. Pressure is then dropped suddenly to atmospheric pressure and, as a result, the paper is torn asunder. While this technology breaks down the waste paper and ink, the process still requires other, more common methods of deinking to remove all the ink, especially if the end product desired is a higher grade sheet, such as newsprint or writing paper.

"Steam explosion replaces the hydropulper and the disperser, and in most cases eliminates the need for flotation cells. It's still in the pilot program phase, though," says Brecc Avellar, technical director for DeNovo, StakeTech's development company.

Other new deinking technologies and challenges come with the rise in office paper recycling. Office paper deinking requires a little more work because much of the material has been printed with laser ink. Five years ago, laser inks made up about 30 percent of all collected office paper; today, 80 percent of the ink on office paper is laser. Just about any high-speed copier or printing machine applies laser inks.

The growing prevalence of laser inks, coupled with the increase in office paper recycling programs, raises the stakes because flotation and washing systems have difficulties removing all the laser ink from the paper.

While together, flotation and washing successfully remove ink particles from one to 150 microns in size, some laser particles are bigger than that. This often requires a way to further break down the size of the particles, such as with a dispersion unit. Dispersion units heat and soften laser inks, then mechanically tear the paper apart.

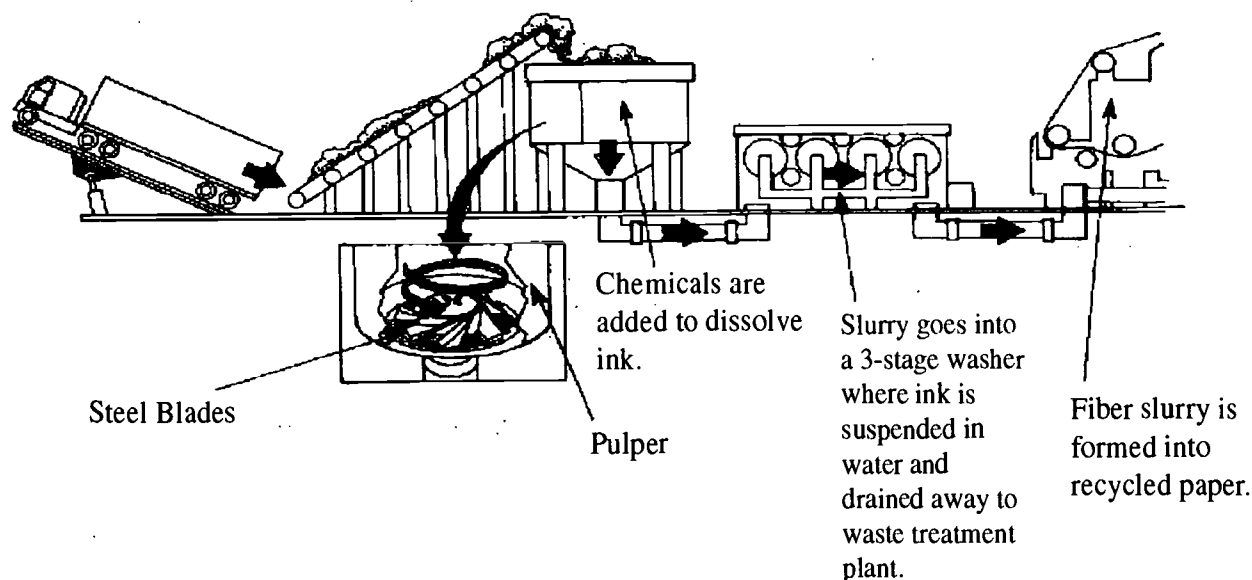
Dispersion breaks the ink and the paper down to more manageable sizes, but the actual units can cost extra. In fact, since paper cannot go directly into a dispersion unit, a series of screens and a flotation cell must come before, and after, the dispersion unit. "To do office waste paper successfully, you have to have a whole second deinking plant," Woodward says.

Another alternative technology to handle laser inks actually makes the ink particles bigger before removing them. The process, which uses centrifugal force, involves chemically altering the ink particles to make them more dense and larger—in the 350-micron and higher range. Once at that size, particles can be thrown to the outside by a centrifugal cleaner. This process separates the ink and the pulp, just as other deinking processes do.

Not all inks lend themselves to any of these processes. The goal of removing ink from paper is still out of reach for some printed items, such as ultraviolet (UV) cured inks. These inks decorate luxury packaging such as perfume boxes with highly colorful designs. UV-cured inks were designed in response to environmental objections to the amount of solvents that were originally being used to make such packaging.

The solution to these environmental outcries was ink that is designed to polymerize in the presence of UV light. Although non-deinkable, packaging blazoned with these inks can be recycled into items such as boxboard or corrugated medium, which don't require ink removal prior to recycling. Perhaps, however, if UV-cured inks become more widespread, deinking technology for those inks will follow.

How Newsprint Is Deinked (Washing Method)



Source: Southeast Paper Manufacturing Co.

Current and Planned Newsprint Deinking Facilities in North America

Company	Location	Capacity (in Tons)	
		Metric	Short
Existing Recycled Newsprint Mills, 1991			
Atlantic Newsprint Co.	Whitby, Ontario	85	94
Augusta Newsprint Co.	Augusta, Georgia	352	388
Bowater, Inc.	Calhoun, Tennessee	733	808
CPFP	Thunder Bay, Ontario	465	513
Fletcher Challenge Canada	Crofton, British Columbia	150	165
FSC Paper Corp.	Alsip, Illinois	132	146
Garden State Paper Co.	Garfield, New Jersey	209	230
Inland Empire Paper Co.	Millwood, Washington	72	79
Manistique Papers, Inc.	Manistique, Michigan	53	58
MacMillan Bloedel Ltd.	Port Alberni, British Columbia	150	165
	Powell River, British Columbia		
North Pacific Paper Co.	Longview, Washington	700	772
Quebec & Ontario Paper	Thorold, Ontario	313	345
Smurfit Newsprint	Pomana, California	129	142
	Newberg, Oregon	361	398
	Oregon City, Oregon	219	241
Southeast Paper Mfg. Co.	Dublin, Georgia	406	448
Spruce Falls Power & Paper	Kapuskasing, Ontario	314	346
Stone Containers Corp.	Snowflake, Arizona	279	308
Total		5,122	5,646

Recycled Newsprint Mill Projects Under Way, 1992-1994

Canadian Pacific Forest	Gatineau, Quebec	440	485
Daishowa Forest Ltd.	Quebec City, Quebec	300	331
Kimberly-Clark Corp.	Coosa Pines, Alabama	310	342
Kruger, Inc.	Bromptonville, Quebec	54	60
	Trois Rivières, Quebec		
Boise Cascade Corp.	Steilacoom, Washington	178	196
Champion International	Houston, Texas	450	496
Donahue, Inc.	Clermont, Quebec	322	355
James MacLaren Industries	Masson, Quebec	191	211
Stone-Consolidated, Inc.	Shawinigan, Quebec	200	220
Evergreen Pulp & Paper Co.	Redrock, Arizona	300	331

Recycled Newsprint Mill Projects Approved But Indefinitely Delayed, 1992-1994

Alabama River Newsprint	Claiborne, Alabama	220	243
(Abitibi-Price/Parsons & Whittemore)			
Bowater	E. Millinocket, Maine	—	100

Source: American Newspaper Publishers Association, with some information supplied by American Papermaker

Why Oil & Water Don't Mix

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 12

Focus: Waste and water, used oil and water pollution, used oil recycling

Subjects: Science (Biology), Chemistry, Auto Shop

Materials: See list of materials itemized below

Teaching Time: One class period

Vocabulary: Aquifers, groundwater, plankton, oil recycling, leachate, surface water

Learning Objective

Students will:

- learn why it is important to recycle used motor oil to prevent it from polluting.

Background

Many of us are concerned with the damage done when a supertanker has an oil spill. Few of us however, realize the environmental impact of our own waste management practices.

- Used automotive oil is the single largest source of oil pollution (more than 40 percent) in our nation's waterways. Most is dumped by people who change their oil.
- In 1960 service stations performed 90 percent of automotive oil changes. Today, about 60 percent of all Americans change their own automotive oil.
- About 1 million gallons of used oil are dumped in South Carolina each year. The used oil is usually dumped on the ground; in trash going to a landfill; or down a storm drain leading to streams, lakes, or the ocean.

- During engine use, oil picks up toxic contaminants, carcinogens, and heavy metals (lead, zinc, arsenic, chromium, and cadmium). If used oil is not properly recycled, these toxics can enter the environment.

- One pint of oil can produce a slick of about one acre on **surface water**.

- Fish, waterfowl, insects, and aquatic life are threatened by used oil in waterways. Floating **plankton** and algae (a basic food source) are killed by oil.

- Very small amounts of oil rinsed over shellfish beds can ruin the taste of clams and oysters. Less than 300 parts per million can spoil the taste of fish.

- Used oil thrown out in the garbage may seep through the landfill to contribute to **leachate** and contamination of **groundwater**.

- One quart of oil can foul the taste of 250,000 gallons of water.

- Used oil can be re-refined into new lubricating oil. (*This re-refined oil is suitable for many applications. Before using re-refined oil in your car, check the owner's manual.*) Oil never wears out, it just gets dirty.



During the Persian Gulf War the various tanker spills amounted to the worst spill since 1978. These tankers spilled 420 million gallons of oil.

source: Oil Spill Intelligence Report 1993

1994 Environmental Almanac

- It takes 42 gallons of crude oil to produce 2 1/2 quarts of lubricating oil. But just one gallon of used oil can be re-refined into 2 1/2 quarts of lubricating oil.
- Used oil can be reprocessed into a fuel oil.
- One gallon of used oil reprocessed for fuel contains about 140,000 Btus of energy and can be burned efficiently.
- To recycle used automotive oil, take it in a clean, sturdy, plastic or metal container with a screw-on lid to the nearest participating recycling center or service station accepting used oil.

For oil recycling locations call the South Carolina Department of Health and Environmental Control's toll-free Recycling Hot Line 1-800-SO USE IT.

The used oil collected for recycling cannot be contaminated. Used oil should never be mixed with antifreeze, gasoline, paint thinner, solvents, cooking oil, or other contaminants, since these interfere with reprocessing and may make the used oil hazardous.

Materials

- A small quantity (a film canister) of either used or new motor oil, lycopodium powder, or sifted flour
- Red tempera poster paint (water based)/or food coloring
- One glass bowl
- One eye dropper
- One funnel
- Very fine aquarium or parakeet gravel or sand (natural color)
- One quart or gallon jar
- One measuring cup
- Water

Questions for the Class

1. When you change motor oil, what should you do with it? What should you *not* do with it? Why?
2. How much crude oil does it take to make 2 1/2 quarts of lubricating oil?
3. How much used oil can be re-refined to make 2 1/2 quarts of lubricating oil?
4. How large an oil slick can one pint of oil produce?
5. What is groundwater? What is the difference between surface water and groundwater ?
6. Used automotive oil contributes what percentage to the total oil pollution of our nations waterways?

Learning Procedure

Note: You may want to substitute sifted flour or lycopodium powder or chalk dust for oil in steps 1 and 2 of the learning procedure.

1. Review with the class the background information with this lesson and the additional information in the Resource section.
2. Have students follow along as you demonstrate how oil reacts on surface water and with groundwater.

Surface Water Demonstration

Fill the glass bowl with water. Place several drops of used oil or lycopodium powder on the surface. Note how the oil spreads across the surface in a thin film. **Ask:** What would happen to marine or freshwater surface organisms like plankton and insect larvae in this water? (*Oil interferes with the life cycle of organisms which use the surface layer as a nursery ground.*)

Ask: Can you get the oil out of the water?

Ask: Could the oil and water be separated now?

Ask: Would you drink this water? Could fish thrive in this water? What would happen if the oil coated their gills? (*They would suffocate.*) What would happen if they absorbed or ingested the toxic contaminants in the oil? (*They could develop skin or liver cancer.*)

Groundwater Demonstration

Tell students that some of the population of South Carolina relies on groundwater for drinking water. Groundwater is not usually in underground streams and lakes. It's usually stored in pores between rocks and gravel. These water-bearing layers are called aquifers.

Put a screen at the bottom of the funnel and pour in 1/2 cup of fine aquarium gravel or sand. Place the funnel in the mouth of a jar. Measure 1/2 cup of water and pour it into the gravel. Measure how much flows into the jar.

Ask: Where is the rest of the water? (*Held in the spaces between particles of gravel. This is how groundwater is stored in aquifers.*)

When someone dumps dirty oil on the ground it can seep into this groundwater. You can taste as little as 1 part per million (ppm).

(*1 ppm = 1 gallon of used oil in one million gallons of water or 1 minute in the life of someone 2 years old.*)

Drop two or three drops of red water-based paint or food coloring onto the water-soaked gravel in the funnel. (*Do not use oil-based paints, because they bond to the epoxy coating on some aquarium gravels.*)

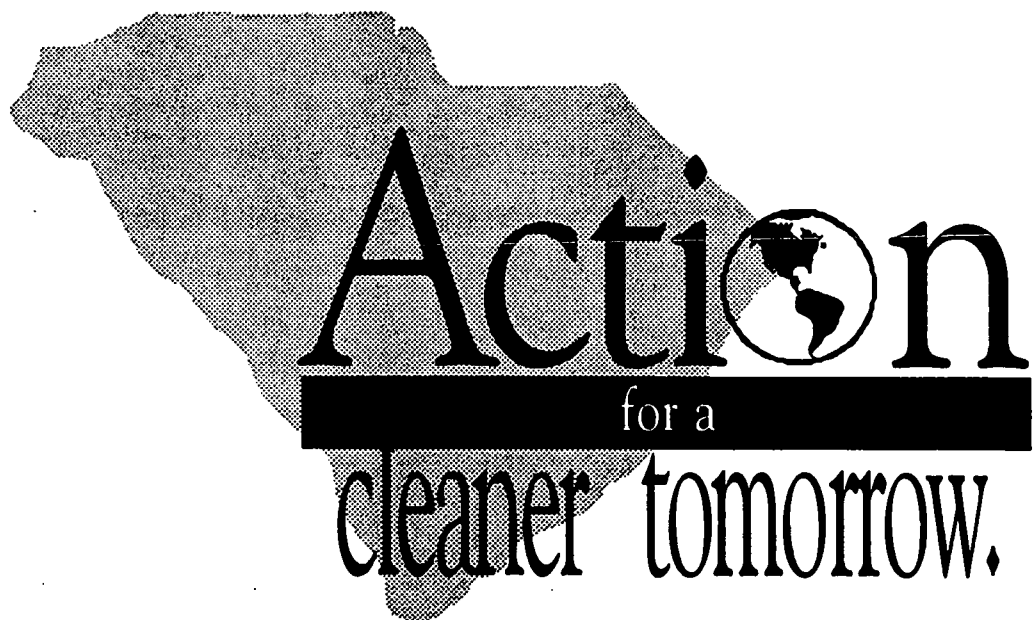
Sprinkle 1/2 cup of water through it (*simulating rainfall*). Note how much oil or paint flushes through and how much remains in the gravel. Pour additional cupfuls of water over the gravel. Note how much water is needed to rinse the gravel clean. **Ask:** Would you want to drink this water?

Ask: Once used oil or other pollutants got into groundwater, how would you get them out again?

3. **Ask:** How can we keep used oil out of surface and groundwater? (*Used oil should be collected in a clean, sturdy, metal or plastic container and taken to a participating recycling center or service station. Never mix it with other liquids! For locations call the toll-free South Carolina Department of Health and Environmental Control's Recycling Hot Line, 1-800-SO USE IT.*)

Just Do It

Investigate used oil recycling in your community. Is there a convenient collection site? If so, work with your school newspaper to see that used oil recycling is promoted. If not, call the South Carolina Department of Health and Environmental Control at 1-800-SO USE IT and see what can be done to establish a site in your area.



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Recycling Used Oil

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 – 12

Focus: Used oil recycling: re-refining and energy recovery

Subjects: Social Studies, Science, Math

Materials: Motor oil in a plastic container, an aluminum funnel, and an oil filter in a paper bag, map of local area or county, sample electricity bill

Teaching Time: One class period, plus student research

Vocabulary: Reprocessing, energy recovery, re-refining



IN SOUTH CAROLINA, USED OIL
THAT WOULD OTHERWISE BE DISCARDED
ILLEGALLY IS NOW BEING COLLECTED
AND TURNED INTO ENERGY.

Learning Objective

Students will:

- examine used oil recycling
- define the benefits of used motor oil recycling to their community
- compute the potential energy savings from recycling oil
- research the logistics of recycling used oil in their community.

Background

The amount of oil dumped by do-it-yourself auto mechanics every four weeks is about the amount spilled by the Exxon Valdez – 11 million gallons.

Forty percent of the oil pollution in America's waterways is from used automotive oil.

According to the American Petroleum Institute, it takes 42 gallons of crude oil – compared to just one gallon of used oil – to make 2 1/2 quarts of virgin lubricating oil.

The properties that make oil a valuable lubricant in your car's engine also make it ideal for recycling by re-refining. Used oil can be cleaned and used again as a lubricant or used as an energy source. Re-refining used oil is on the increase in the United States.

According to the United States Environmental Protection Agency (EPA), the vast majority of used oil collected is **reprocessed** – processed again – into fuel oil. Reprocessing involves removing impurities from the used oil and blending it with crude oil to make industrial grade heating fuel. Reprocessed used oil is often sold to industries such as asphalt plants, cement companies, and steel mills at lower prices than the price of fuel oil made from virgin crude oil.



The Exxon Valdez oil spill in 1989 killed 350,000 to 390,000 seabirds, according to the General Accounting Office report to Congress.

Source: 1993 Environmental Almanac

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Give Oil For Energy Recovery

In South Carolina, used oil that would otherwise be discarded illegally is now being collected and turned into energy.

In a process called **energy recovery**, much of South Carolina's used oil is burned as a fuel source in generating electricity. Resource recovery is the process of obtaining material or energy resources from solid waste which no longer has any useful life in its present form and preparing the waste for recycling.

Through energy recovery, used motor oil yields nearly twice the energy-producing value of coal. The U.S. EPA considers this form of used oil collection and use to be a form of recycling.

One gallon of used oil can be recycled to generate 18 kilowatthours of electricity. Multiply this energy potential times the estimated 1 million gallons of used oil disposed of improperly in South Carolina each year and you'll get 18 million kilowatthours of electricity. This is enough to power nearly every household in South Carolina for about a week.

According to Santee Cooper, South Carolina's state-owned electric utility, just two gallons of used oil will provide electricity to run the average household for about 24 hours or...

- Cook 48 meals in the microwave
- Blow dry your hair 216 times
- Watch TV for 180 hours or for 24 hours a day for seven and one-half days!

Santee Cooper has GOFER oil collection sites across South Carolina. There are used oil collection sites in each of the state's 46 counties.

How Used Oil Recycling Works in South Carolina

People from throughout the state take their used motor oil to collection sites. This oil is collected from these sites and taken to an energy recovery facility.

In the GOFER (Give Oil For Energy Recovery) program, four days each week the GOFER truck travels to eight to twelve sites and collects an average of 2,000 gallons of used oil. A special vacuum tanker collects the oil. The truck is off loaded at either the Winyah Generating Station in Georgetown or the Jefferies Generating Station in Moncks Corner. Oil is stored in a 20,000 gallon tank at Winyah and a 2.3 million gallon tank at Jefferies.

The oil is burned in the coal-fired boilers as a supplementary fuel – that is, it is used in addition to the coal used to produce the fire that creates the steam that turns the turbine to generate electricity. The used oil is introduced after the boiler has reached normal operating temperature, or about 2,500 degrees Fahrenheit.

There may be some trace elements, usually heavy metals, associated with used oil that cannot be combusted when the oil is burned. The generating stations are equipped with devices that remove the vast majority of these elements. Regular testing has demonstrated that these stations exceed U.S. EPA standards for emissions.

The South Carolina Solid Waste Policy and Management Act of 1991 contains standards for used oil generators, collection facilities, processors, re-refiners, and the companies that burn used oil. South Carolina's regulations are similar to the used oil regulations published by the U.S. EPA.

Because the additives and contaminants in used oil can be toxic, the Act also specifies maximum allowable levels for certain properties including arsenic, cadmium, chromium, lead, and halogens. The Act also specifies that used oil have a flash point of 100 degrees Fahrenheit minimum.

In addition to regulating the disposal of used oil, the Act also specifies regulations for used oil filters. Before filters can be placed in the trash (then on to the landfill), they should be drained and crushed to remove oil (about four ounces) and the oil recycled.

Several communities in South Carolina also collect used oil filters as part of their used oil recycling programs. For example, in Lexington County, more than 2,200 used oil filters were collected for recycling in just six months. These collection sites forward the used oil filters on to companies that specialize in handling them.

These filters are diced and sliced into small pieces and sorted into three components: oil, steel, and fiber material. The oil is sent for recycling.

The metal is removed and recycled into new steel products. The fiber material is processed and sent to waste-to-energy facilities which produce electricity.

On the Road Again

Beyond recycling used oil into heating fuel or burning it for energy recovery, advanced recycling methods **re-refine** used oil so that it can be reused as a lubricant.

Re-refining technology has improved over the past five years. According to the National Institute of Standards and Technology, re-refined lubricating oil meets the same standards as lubricating oil made from crude oil.

While re-refining used oil into lubricating oil is considered by many environmentalists as the preferred use of used oil, only a small percentage of used oil collected is re-refined. Currently, re-refined motor oil is not recommended by all automakers. Before re-refined motor oil is purchased, owners should consult their vehicle's operating manual.

According to an article in *Resource Recycling*, "Economics of used oil recycling," September 1992, "used oil recycling (non-burn) will nearly double in the next two years. But even then, less than 0.003 percent of the 1.35 billion gallons of used oil generated (from private and industrial sources) annually will make it through the recycling loop."

The article surveyed current used oil recycling facilities and facilities in the planning stages. Concerns of used oil re-refineries include difficulties in controlling used oil supply and quality.



RE-REFINING USED CRANKCASE OIL

The technology that re-refines used oil was first used in Europe. According to company brochures from Evergreen Oil, one of the country's seven oil re-refiners, a six-step process transforms used crankcase oil into a premium grade oil similar to virgin oil.

Step One: Pretreatment - this step is proprietary.

Step Two: Atmospheric Flash - water, gasoline, and other light boiling components are removed with heat.

Step Three: Vacuum Distillation - diesel fuel and gas oils are removed from the oil by applying a vacuum during heating.

Step Four: Thin Film Evaporation - dirt, polymers, heavy metals, and other toxic contaminants are removed as heat and vacuum pressure increases. The residue from this stage is an acceptable replacement for certain virgin asphalt products.

Step Five: Hydrofinishing or Polishing (a process also used in the refining of virgin oil) - at high temperatures, under pressure and in the presence of a catalyst, the lube oil is processed with pure hydrogen gas. The gas bonds with trace elements such as sulphur, chlorine, and others that might color or contaminate the oil.

Step Six: Fractionation - This process splits the lube oil into two separate grades of viscosity.

This process yields 65 percent lube oil, 15 percent asphalt flux, 10 percent waste water, and 10 percent fuels.

The wastewater is treated before disposal.

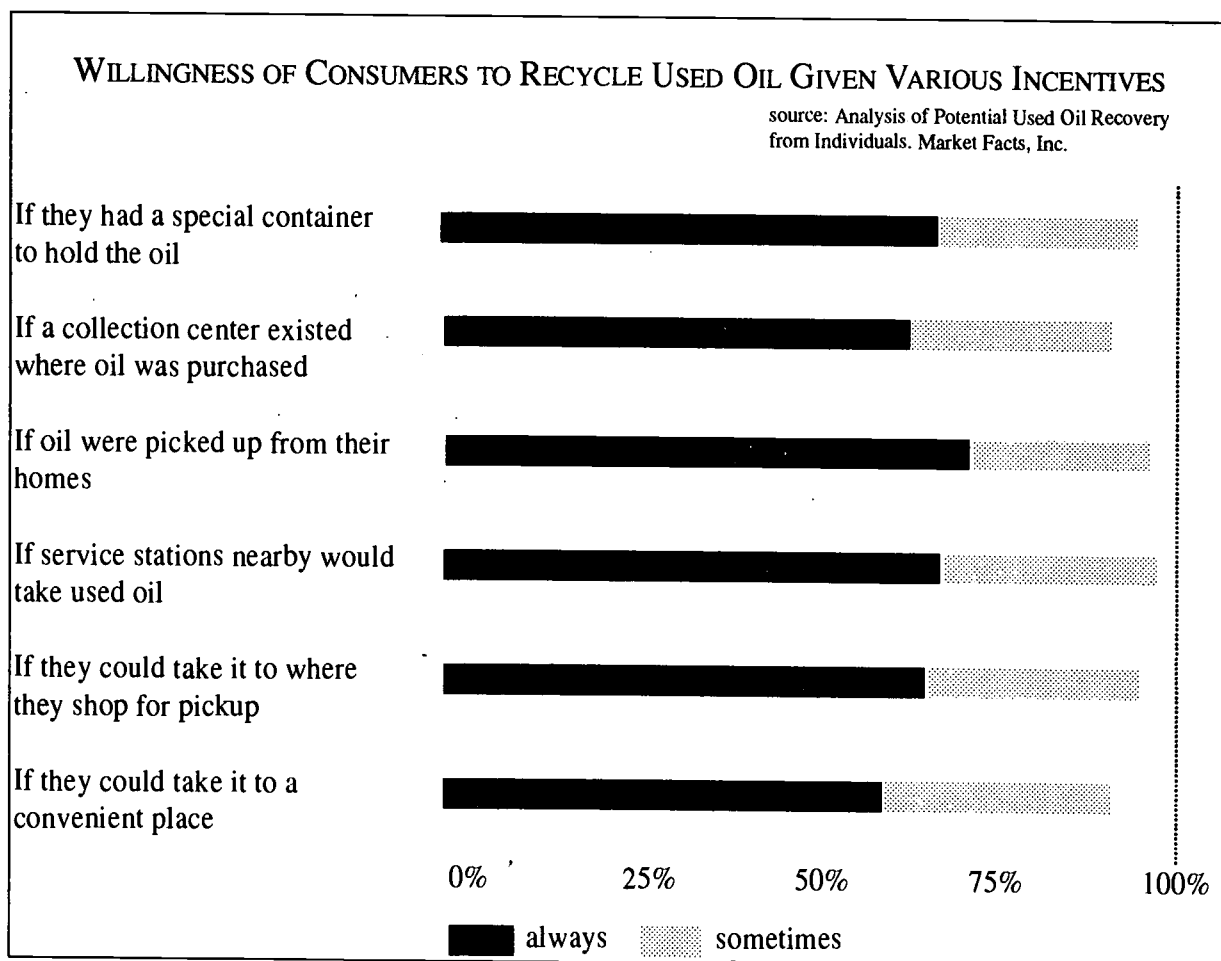
The technology of re-refining is changing and keeping pace is expensive. Companies are also concerned about complying with environmental regulations. To be large enough to achieve economies of scale, re-refineries are getting larger. The largest oil re-refinery is owned by SafetyKleen Corporation. The 75-million gallon annual capacity facility in East Chicago cost the company \$50 million when it was built in 1991. SafetyKleen and Evergreen Oil currently re-refine used crankcase oil into lube oil. The other five re-refining companies produce fuel oils, gasoline, and asphalt flux.

In 1993, Texaco Inc. announced construction of the company's first used oil recycling center to be built in Louisiana. The \$7.2 million facility will process as much as 147,000 gallons per day of used motor oil and industrial lubricants into distillate fuel oil.

Learning Procedure

1. Before reviewing the background information with the class, show students a bottle of ordinary motor oil in a plastic container, an aluminum funnel, and an oil filter in a paper bag. Explain to students that these are just some of the items that you might use during a typical oil change.

Ask: From these items, what would you expect to be able to recycle? List student responses on the board. Students should consider that the plastic, aluminum, and paper bag may be recyclable. Students may not think to include the motor oil as a recyclable item or the oil filter. If students do not mention the oil filter or the oil, **ask:** What valuable natural resources were used in creating the items? Students should mention the petroleum used to create the plastic bottle, the bauxite used to make the aluminum, the trees used to make the paper.



Ask: What about the petroleum used to make the motor oil? Is it a valuable resource like the petroleum used to make the plastic? Explain to the class that motor oil is a valuable resource that can be recycled.

Review with the class the background information included with this lesson.

2. Tell students that in South Carolina recycling used oil creates energy. More than 600,000 gallons of used oil have been collected and recycled into energy through the S.C. Used Oil Partnership's used oil recycling program.

On the board write:

One gallon of used oil can be recycled to generate 18 kilowatthours of electricity.

Ask: What is a kilowatthour? (*A kilowatthour is a unit of energy equal to the power of one kilowatt acting for one hour, that is the amount of electrical energy consumed when 1,000 watts are used for one hour. One kilowatthour is the amount of electricity that an operating 100-watt light bulb would consume in 10 hours. It is the equivalent to 3,411 Btus.*)

Multiply the energy potential in a gallon of used oil times the estimated 1 million gallons of used oil disposed of improperly in South Carolina each year and you'll get 18 million kilowatthours of electricity. This is enough to power nearly every household in South Carolina for about a week.

3. Hold up the map of your local area or county.

Ask: How many people live in this area? Write the number on the board.

Ask: How many people in this area do you think change their own oil? Write students' estimates on the board. Explain to the class that studies show that:

- about five or six out of every ten people, or 50 to 60 percent, can be classified as "do-it-yourselfers" who change their own motor oil
- of these "do-it-yourselfers" about half change their oil frequently and half are

considered to be infrequent, for an average of 6.6 oil changes per year per person

- the average oil change yields about one gallon of used oil
- more than 60 percent of all do-it-yourself used oil is improperly disposed
- each gallon of used oil can be used to generate 18 kilowatthours of electricity.

Working with the class and using the percentages above, figure out for your area:

- the approximate number of do-it-yourselfer oil changers
- the number of do-it-yourselfer oil changes per year
- the approximate number of gallons of used oil that are improperly disposed of each year
- the potential energy created in kilowatthours if all used oil generated by do-it-yourselfers in your area was recycled for energy recovery.
- the potential value of the energy created (use your electricity bill to figure the cost per kilowatthour and multiply times the total number of hours.)

4. **Ask:** If recycling used oil creates energy and prevents pollution, why doesn't everyone recycle their motor oil? Write students' responses on the board.

Tell students that studies have shown that the primary reasons that people do not recycle their used oil is that they are unaware that used oil can cause environmental problems if disposed of improperly. These people put their used oil in the trash, pour it on their yard, keep it, pour it down the sewer or other now illegal disposal methods.

From a study done in another state, of the people who were aware of used oil collection facilities but did not take their oil for recycling, more than half said they did not know the location of a recycling site.

Ask: Do you know the location of a used oil recycling site in our area? Use your map of the area to pinpoint locations that students mention.

Ask: What do you think our area can do to promote used oil recycling? What can we do to promote it? See the chart, *Willingness of Consumers to Recycle Used Oil Given Various Incentives*. **Ask:** Does our community offer any of these or other incentives?

5. Assign students to research the used oil collection in your area. Have the class research:

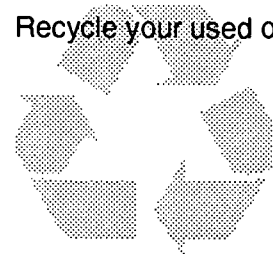
- the locations of the used oil collection sites in your area
- how these collection sites are being promoted.

Extension Activity

Promote used oil recycling at school. Have students design flyers to educate their families about used oil and used oil filter recycling in your area. Be sure to include the locations of local recycling sites.

Just Do It

Recycle your used oil!



Changing the Way You Change Your Oil

Preparation Time: Easy-To-Do Moderate Extensive

Grade: 6 – 12

Focus: How to change your engine oil responsibly

Subjects: Driver's Training, Auto Shop, Graphic Arts

Materials: *10 Steps for Changing Your Oil*
Properly handout, Art in Communicating Used Oil
Recycling transparency, art supplies to make posters

Teaching Time: One class period

Learning Objective

Students will:

- learn how to change the oil in a car with used oil recycling as a part of the procedure.

Background

For many decades, motorists simply took their cars to full service stations for oil changes and all routine maintenance. For those that preferred to do their own car maintenance and oil changes (do-it-yourselfers), these full service stations also sold motor oil and other car maintenance items and accepted their customers' used motor oil back as a service.

During the 1960s, motor oil marketing and distribution patterns changed radically. Service station sales gave way to sales by mass merchandisers and other retail outlets, such as Kmart and other discount chains. These retailers offered oil to their customers at greatly reduced prices as a result of large volume discounts. Many stores began using oil as a promotional item to attract customers, selling oil as a "loss leader" – an item that is sold below cost to lure customers while the losses are made up on other items.

At the same time discount houses were offering bargain prices for motor oil, many full service stations began scaling back automotive

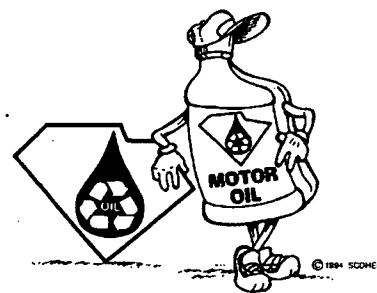
maintenance and repair services and became quick, convenience-oriented "gas stations." Most of these gas stations did not accept used oil.

In 10 years, from 1960 to 1970, service station sales of motor oil dropped from 70 percent of all sales to about 50 percent. By 1989, mass marketing retail stores outsold service stations eight to one. This left the majority of the do-it-yourselfers with the problem of disposing-of-it-yourself as well.

Today, it is estimated that do-it-yourselfers produce some 210 million gallons of used oil nationally, and only about 32 percent of this used oil is properly collected and recycled.

Mismanaged used oil represents a serious environmental problem. Do-it-yourselfers dump the equivalent of about 14 Exxon Valdez spills each year – that's about 143 million gallons of used oil that ends up contaminating our land and our water. While each person tossing out an occasional pan of used oil might not seem like it could do any harm, it all adds up.

As much as 20 percent of automotive oil is additives. These improve performance, inhibit rust, and prevent foaming. Oil will also pick up sediment and gasoline components.



In 1993, President Clinton established the Council on Sustainable Development to formulate U.S. policies that encourage economic growth, job creation, and effective use of natural and cultural resources. The council's primary goals will be to recommend a national strategy for achieving sustainable development as outlined at the 1991 United Nations Earth Summit.

Source: *State Recycling Laws Update*

9 - 12
PAGE
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Materials

To conduct lesson for Auto Class and Driver's Training

- Facilities and materials needed to perform an oil change, including a clean, sturdy metal or plastic container with a screw-on top for collecting used oil and a container for the oil filter
- Information on local used oil recycling stations
- Handout *10 Steps for Changing Your Oil Properly*.

To conduct lesson for Art Class

- Creative art supplies for making banners, posters and/or calendars
- Information on local used oil recycling stations
- Handout *10 Steps for Changing Your Oil Properly*
- *Arts in Communicating Used Oil Recycling* transparency or handouts.

Learning Procedure

For Auto Class and Driver's Training

1. Review with the class the background material with this lesson and the information provided in the Resource section. **Ask:** Why do we change engine oil? (*It gets dirty and this dirt interferes with engine performance and can damage parts.*)

Explain that oil does not wear out. What does wear out are all the engine additives that go into today's high performance motor oils.

2. Demonstrate the Environmental Protection Agency's *10 Steps For Changing Your Oil Properly*, see the handout with this lesson for instructions.

Questions for the Class

1. Why do we need to change engine oil?
2. What should we do with used motor oil?
3. What should we do with used oil filters?
4. Why is used motor oil an environmental concern?

For Art Class

1. Review with the class the background material with this lesson and the information provided in the

Resource section. **Ask:** How can we use graphic arts to help people learn to change the way they change their oil to incorporate used oil recycling? (*Create visual reminders such as banners, posters, point-of-purchase displays, and calendars to display in home garages and service stations, modify the directions on motor oil bottles, etc.*)

2. Project the transparency *Arts in Communicating Used Oil Recycling* showing how different organizations have used visuals to communicate their used oil recycling messages. Discuss how these images might be effective.

3. Have students design their own used oil recycling graphics and complete a project such as:

- A poster to hang in a home garage appealing to a family with the message of used oil recycling
- A calendar to remind people to change their oil at regular intervals and to dispose of it properly
- A banner to hang in the school auto shop to promote used oil recycling
- A brochure on the environmental responsibilities of owning and maintaining a car aimed at first-time drivers
- An ad for the school paper promoting used oil recycling.

For all the graphics arts projects, it is useful to include local information on used oil recycling sites. Encourage students to complete finished quality projects and arrange to have them displayed.

Extension Activity

Share with the class the information in the article, "Driving Green," from the *Green Consumer*.

Just Do It

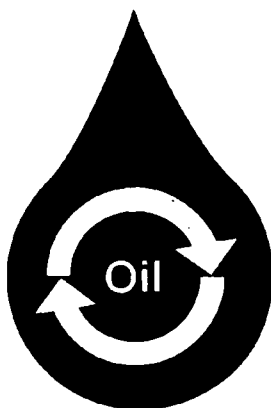
Find out what your school district does with its used oil from changing the oil in buses. Encourage recycling!

10 STEPS FOR CHANGING YOUR OIL PROPERLY

from the United States Environmental Protection Agency brochure, *Recycling Used Oil*

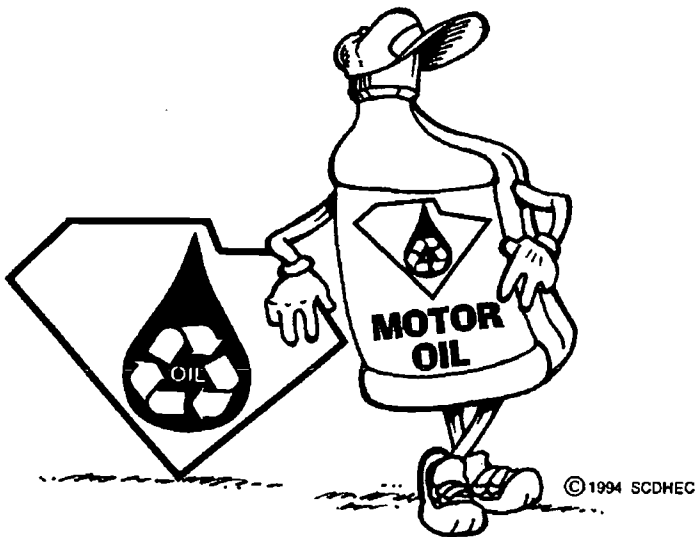
Change the oil after the motor has warmed up. The oil will drain more quickly and completely if it's warm.

1. Turn off the engine, block the wheels, and apply the parking brake before getting in the car. To avoid burns, make sure the engine is not too hot. Consult your owner's manual for directions.
2. Remove the drain plug on the bottom of the oil pan, allowing the old oil to drain into your pan. After the oil is finished draining, replace the drain plug and tighten.
3. Use a filter wrench (if necessary) to loosen the old filter, then spin it off, and drain as much oil as possible out of the filter in to your drain pan.
4. Using a drop or two of new oil, coat the rubber seal on the new filter with oil, then spin it on. **Do Not Use A Filter Wrench** to tighten the new filter. Tighten it snugly with your fingers, following the directions supplied with the filter. Replace the oil plug and make sure it's tight.
5. Before adding new oil, check to make sure the drain plug has been replaced. Add the new oil. (Most cars take 4 or 5 quarts, but check the owner's manual.) **Do Not Overfill.**
6. Start the engine. The oil pressure warning light may be on, but should go out after a few seconds. Let the engine run a few minutes.
7. Turn the engine off and check the oil level. Also, check around the filter and drain plug for leaks.
8. Write down the date and mileage as well as the type and brand of oil you installed on a doorjam sticker or a record book.
9. Using a funnel, pour used oil into a clean, empty, sturdy plastic or metal container with a tight, screw-on lid. Consider purchasing a 5-gallon metal or plastic container to use for collecting and transporting your used motor oil. Do not mix it with other substances, such as gasoline, paint stripper, or pesticides.
10. Recycle the used oil by taking it to a facility that offers collection services.

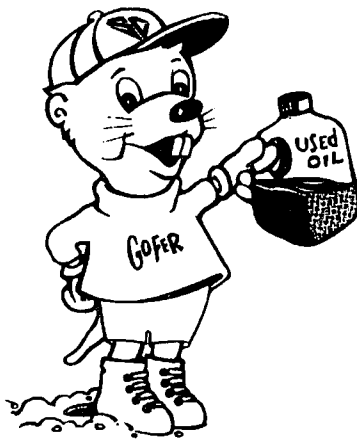


In South Carolina,
call 1-800-SO USE IT
for the used oil recycling locations
in your area.

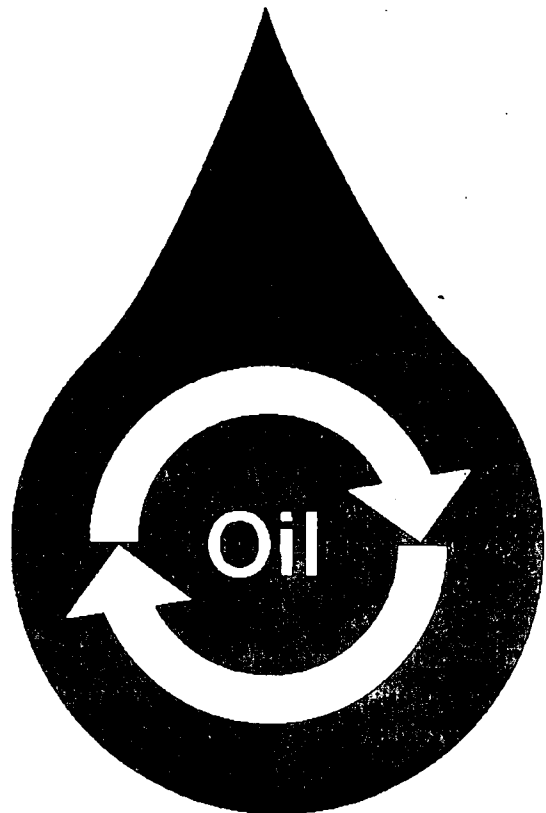
ARTS IN COMMUNICATING USED OIL RECYCLING



The South Carolina
Used Oil Partnership's
mascot.



Santee Cooper's
mascot for the
Give Oil For Energy
Recovery (GOFER)
program.



This symbol is used in South Carolina
and nationally to represent used motor
oil recycling.

DRIVING GREEN

The fact is, most of us drive pretty inefficiently. We don't do it on purpose. A lot of it has to do with our lifestyles. Statistics show that the average automobile trip in the United States is about 9 miles. And it's during those very same miles — the first few minutes of driving — that your car uses a lot of gas and creates a lot of pollution.

Why is this? When your car's engine is cold, it requires a higher ratio of gasoline to air to operate. More gas equals more air pollution.

Another problem is that gasoline needs to be heated up and turned into vapor to work in the engine. Needless to say, things don't heat up as easily in a cold engine and a surprising amount of the gas never gets vaporized. It simply trails out the tailpipe in its original liquid form. Of course, that creates even more pollution.

Other engine parts also need to be warmed up to work efficiently. Consider catalytic converters. These are remarkable little devices, the most successful technology ever invented to curb air pollution. In fact, today's catalytic converters eliminate 96 to 98 percent of carbon monoxide and hydrocarbon, and three-quarters of the nitrogen oxide emissions.

How do they do this? Catalytic converters work by burning up pollutants, converting them into three basic elements: carbon dioxide, water, and nitrogen. That's all there is to them.

The bad news is that catalytic converters need to be warmed up to do their work. So until a car's engine is warmed up, the burning process is incomplete. Indeed, when you first start a cold engine, the converter is too cold to burn anything. Virtually all the pollutants are emitted through the tailpipe.

Here's the bottom line: During a typical 20-mile commute, half of the hydrocarbons will be emitted during the first three or four miles. Reducing cold starts and short trips are the two most important things you can do to increase gas mileage and decrease pollution.

Getting Off To A Cold Start

How do you avoid these problems? Here are four suggestions:

- Learn the proper way to start your engine. You'd be surprised how much fuel is wasted by pumping the gas pedal when starting a car. If your car has fuel injection, you usually don't need to press the pedal at all when starting. If your car is in tune, it should start right up, even when it's cold outside. Cars with carburetors may require pumping the gas once, maybe twice.
- Don't warm up your car by idling. Idling a cold car will increase engine wear and tailpipe emissions. If your car has been properly tuned and is otherwise in good shape, you needn't idle your car more than a few seconds before taking off. Those first few minutes of driving will do more to heat up the engine — and get the catalytic converter working — than anything else.
- Start driving slowly. You shouldn't go from 0 to 60 during those first few minutes. Try not to go over 35 miles per hour for the first minute or so.
- Don't turn on the heat right away. This may be difficult to do on a bone-chilling morning, but doing so will rob your engine of precious heat during those first few crucial minutes. Try to wait three or four minutes before turning up the temperature.

Green Driving Tips

- Observe speed limits. The typical car uses 17 percent more gas when driven at 65 miles per hour than at 55 mph. Most cars get their best gas mileage somewhere between 35 mph and 45 mph.
- Avoid jump starts. Never put the "pedal to the metal," unless your life is in danger. Doing so can burn as much as 50 percent more gas than a relatively smooth start. Flooring it sends more gas than the catalytic converter is able to deal with. The result: Wasted, unburned gas is emitted through the tailpipe—and into the air.
- Accelerate smoothly and moderately. Speeding up and slowing down waste gas. Here's a trick: Pretend there's a full glass of water sitting on the seat next to you. Get the car to cruising speed without spilling any of it.

- **Lose some weight.** Remove unneeded stuff from your trunk. The lighter the car, the less gas it uses. An extra 100 pounds decreases fuel economy by about 1 percent for the average car, slightly more for smaller cars.
- **Use cruise control.** If you have this option, use it on the highway to help even your speed and reduce your gas use.
- **Don't ride your brake.** This is unsafe, it wastes gas and prematurely wears down brake pads and shoes. When you see a red light or stop sign ahead, or otherwise know you'll be stopping the car, take your foot off the gas well in advance.
- **Don't idle.** When your car is idling, it is getting zero miles per gallon! If you must stay in one place for more than a minute, turn the engine off.
- **Don't tailgate.** Following too closely requires much more braking and accelerating.
- **Plan your trips.** Consolidate errands, avoid congested areas, and avoid needless driving.
- **Turn off your air conditioner.** Driving with the air conditioner on can waste up to a gallon of gas per tankful, especially in city traffic.
- **Learn how to shift.** The goal is to get into high gear as quickly as possible without straining your engine.
- **Maintain momentum.** It takes energy to accelerate, of course, so the less you have to brake, the less you'll have to accelerate to regain speed. It takes 5 to 6 times as much gas to get a car rolling from a dead stop than when it's already rolling, even at a few miles per hour.
- **Avoid peak-period travel.** When average speeds drop from 30 to 10 mph, fuel consumption doubles.

KEEPING YOUR CAR RUNNING GREEN

Here are some tips on keeping your car running longer — and polluting less.

- **Check your tires.** Simply keeping your tires inflated can save gas and tire wear. Underinflated tires can decrease fuel economy by as much as 5 percent.
- **Don't skimp on oil filters.** Always buy top-of-the-line brands. Cheaper filters don't screen oil as thoroughly and can clog over time. When that happens, the oil goes through the bypass valve — sending unfiltered oil into the engine, which could harm it.
- **Go permanent.** Even better, consider buying a permanent oil filter. They may cost about \$100, but are supposed to last for up to 100 oil changes, a considerable savings over the \$5 or so you pay for a disposable filter. A permanent oil filter also helps cut the number of filters ending up in landfills. Almost 400 million filters are disposed of each year, each of which may contain up to a cup of oil. Cleanable and reusable air filters are also available.
- **Go platinum.** Platinum spark plugs, which cost 2 to 3 times as much as conventional plugs, last up to 100,000 miles — far longer than regular plugs do. That means you'll need to change them less, which will save money in reduced maintenance costs. As plugs wear out, they affect the engine's timing, reducing gas mileage. Because platinum plugs wear out much more slowly, they can boost fuel economy.
- **Buy parts for a lifetime.** Ask your mechanic to buy parts that have a lifetime warranty, such as brake parts, water pumps, alternators, and starters. They usually don't cost much more than other parts. While they may not actually last a lifetime, these parts are usually better built and manufacturers will usually replace them if they break.
- **Read year owner's manual.** You may have seen it buried somewhere in your glove compartment or at the bottom of a clutter drawer. Owners' manuals contain a gold mine of information on how to keep your car running at peak performance.

Getting the Word Out About Used Oil

Preparation Time: Easy-To-Do Moderate Extensive

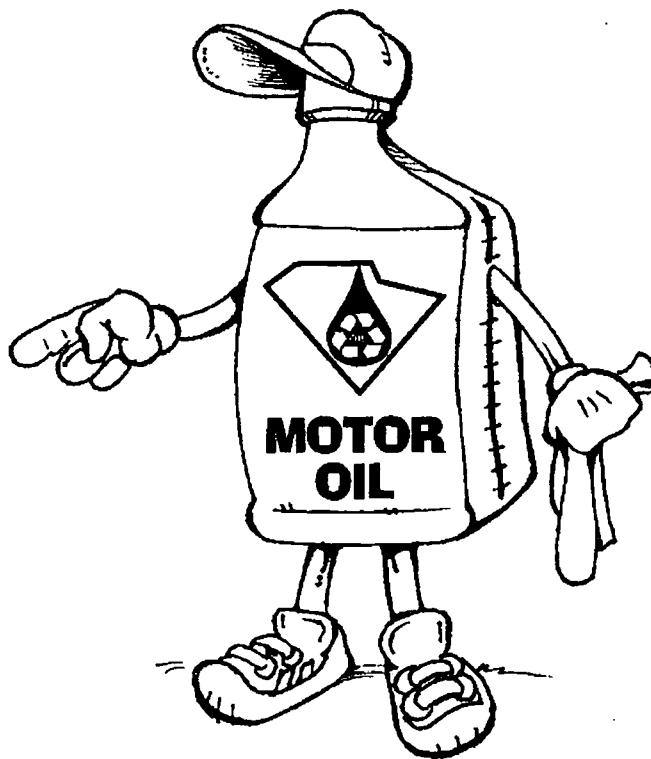
Grade: 9 – 12

Focus: How public awareness of used oil recycling can change attitudes and habits.

Subjects: Language Arts, Social Studies

Materials: Handouts included with this lesson, student materials to produce public service campaign

Teaching Time: Several class periods, plus student research, surveys and projects



Learning Objectives

Students will:

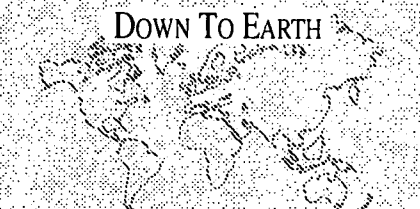
- survey their community to determine the level of awareness of used oil recycling, measure perceptions or misperceptions of the used oil problem in their area, determine the willingness of the survey group to recycle used oil
- create a local public information campaign to educate students and/or adults to the benefits of used oil recycling.

Background

South Carolina law makes it illegal to dispose of used motor oil in municipal landfills or to dump it on the ground or in waterways. This law, part of the South Carolina Solid Waste Policy and Management Act of 1991, also provides for fines to be imposed for improper used oil disposal.

While enacting a law to safeguard the environment from the pollution caused by improper disposal of used oil is an important step, it is equally important to see that the public is *made aware* of the law, *understands* what to do with their used oil, and is *motivated* to recycle it.

According to "Put Used Oil In Its Place," a plan for public education by the American Petroleum Institute in Washington, D.C., "a solid information effort is essential to the success of any used oil recycling program." According to the United States EPA publication, "How To Set Up A Local Program to Recycle Used Oil," publicity about used oil recycling can triple do-it-yourselfer participation in recycling programs.



DOWN TO EARTH

A survey by the U.S. Department of Energy found that 75 percent of do-it-yourself oil changers would recycle their oil if there were a facility nearby.

Source: *50 More Things You Can Do To Save The Earth*

Since the State of Washington began a public education program, it increased participation in its used oil collection program by more than 21 percent in a single year.

The S.C. Used Oil Partnership launched a public information campaign in 1992 to educate the public about the availability and importance of used oil recycling in this state. Using NASCAR race car driver Kyle Petty as the spokesperson, and the slogan, "Don't Pour Your Future Down the Drain," the campaign featured public service television, newspaper and radio; posters and billboards; press conferences and press releases; and personal appearances around the state. In addition, Santee Cooper, the state-owned public utility and a member of the S.C. Used Oil Partnership, aggressively promotes its GOFER (Give Oil For Energy Recovery) program while contributing to the statewide campaign.

South Carolina's program proved to be a success with more and more people recycling used oil at a growing number of drop-off stations. In its first year of operation, the program achieved impressive numbers: about one-fourth, or 250,000 gallons, of the 1 million gallons of used oil that is improperly disposed of in South Carolina was collected for recycling. More than 1 million gallons of used motor oil has been collected overall.

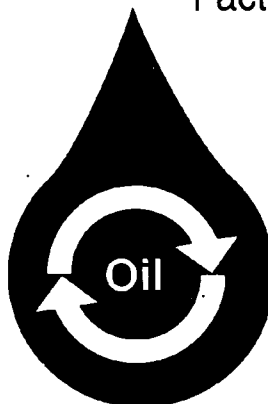
A new campaign featuring NASCAR driver Jeff Gordan was kicked off in 1996.

Just Do It

Don't Pour Your Future Down the Drain!

If you or any one in your family is a do-it-yourselfer, see that your used oil gets recycled!

Facts about Used Oil



- Improper disposal of used oil costs you money. You pay in taxes for environmental cleanups and increased health care costs when wastes are improperly managed.
- Recycling used oil saves money and protects the environment.
- According to the U.S. EPA, listing of used oil as hazardous waste is not necessary because the toxicity characteristics rule in place already controls hazardous components that may be in industrial used oil. The agency believes that this approach is the most practical one for protecting human health and the environment while encouraging and promoting recycling of this valuable resource.
- The S.C. Solid Waste Policy and Management Act of 1991 prohibits the disposal of used oil in county and municipal landfills. The Pollution Control Act makes dumping used oil on the ground or in waterways illegal. If you are caught violating either of these laws you can be fined up to \$200 or \$10,000, respectively.
- Each year about 1 million gallons of used motor oil are improperly disposed by "do-it-yourself oil changers" in South Carolina.
- Through programs of the S.C. Used Oil Partnership about one-fourth of this used oil was collected and recycled in the program's first year.
- The majority of the used oil collected in South Carolina is burned as a fuel substitute for coal to generate electricity at Santee Cooper generating facilities. Facilities have been modified to accept used oil as a fuel source and to meet or exceed all U.S. EPA regulations.
- There are more than 250 used oil collection sites across South Carolina. To locate the used oil recycling station in your area call 1 800 768 7348.

Learning Procedure

Part One: Designing a survey to determine a baseline of information.

1. **Ask:** What do you think people in our area do with their used oil? (*List student responses on the board. Encourage students to consider local influences and habits such as rural people changing oil in farm equipment.*)

Ask: Do you think people in our area are aware that they should be recycling their used oil? How can we find answers to these and other questions about the public's knowledge and perceptions of used oil recycling?

Tell the class that one way that public perceptions are measured is with surveys. Surveys ask a sample of the population questions and then take their answers and extrapolate them to make assumptions about a larger population. For example, to survey a school population of 2,000 students it would not be necessary to survey all 2,000 people to have a meaningful survey. Surveying a random sample of about 400 would yield results that are considered reliable. This would yield an error rate of about 4 percent. Sampling 300 would increase the error ratio to about 5 percent, still an acceptable level.

Surveys are an important part of comprehensive public information campaigns. After all, it is important to know what attitudes are before you set out to change them. Many times surveys are done initially as a baseline before campaigns and then are repeated to measure results.

Tell the class that they are going to design and conduct a survey to find local answers to used oil recycling questions. These answers will be useful in the second half of this activity as students use this information in developing their own public information campaign to promote used oil recycling.

Divide the class into teams of about five students each. Have each team design a survey to determine the level of awareness of used oil recycling, measure some of the misperceptions of the used oil problem in their area, and gauge the willingness of local people to recycle used oil.

Share with the class examples of questions that may be asked, survey methods, and ways to evaluate survey results.

For example, the S.C. Used Oil Partnership participated in the 1993 State survey conducted by the University of South Carolina's Institute of Public Affairs. They asked 11 questions of more than 800 people to find out if their campaign to promote used oil awareness has been effective. This survey reached people across several demographic subgroups – sex, race, age, education, income, area, and region.

Some of the questions the survey asked were:

- Do South Carolina municipal landfills accept used motor oil?
- How important is proper disposal of motor oil? Why?
- Have you seen or heard any promotions about recycling used motor oil? If yes, where did you see them?
- Do you change your own oil?
- Have you ever recycled used oil at an approved collection station?

These questions were asked in a telephone survey. The sample error potential was plus or minus 3.5 percent, which is considered to be reliable.

Florida conducted a similar telephone survey. They asked:

- Do you change your own oil? How often?
- Are you aware of Florida's used oil disposal problem?
- How do you dispose of used oil?
- What do think would be the most environmentally correct way to dispose of used oil?

Florida conducted 400 random telephone surveys with a sampling error potential of plus or minus 5.8 percent for some questions and 9.8 percent for others.

Students should be encouraged to think of their own survey questions based on their community. Students may also want to target a certain sample population to survey such as students of driving age or students of nondriving age, or just women, or just men.

Survey methods students should consider include telephone surveys, personal interviews (such as surveying people at the mall), or direct mail surveys (these take time and may not yield many returns.)

Note: Students will need parental permission and should be required to be prepared and rehearsed before calling, interviewing, or writing to any one. Students should clearly identify themselves and their reason for conducting the survey. They should be polite at all times. They should politely thank any one who declines to participate.

Suggest that students limit the scope of their surveys to those questions that can be asked, answered, and answers recorded in about five minutes. Have students create their survey forms in advance and test them for ease of use before conducting their official survey. Remember to target the survey to a defined demographic group.

You may want to set a minimum number of people for students to survey, such as 25. Although this number may not offer a sample size large enough to gauge public perception with any accuracy, conducting the survey will provide meaningful input for producing their public information campaign.

Have students tabulate the results of their surveys. See the survey results charts included for examples of how information may be presented. Have student teams share their findings with the class.

Learning Procedure

Part Two: Producing a public information campaign

1. **Ask:** What is the best way to get people to recycle their used oil? (*You may want to list ideas on the board. Students may mention advertising, stories on the news, billboards, etc.*)

Explain to students that there are many possible strategies to carry the message of used oil recycling. These strategies can include:

- creating alliances with a variety of community groups that can help support the program and extend its reach, for example teaming up with local citizen or environmental groups that already have a network
- developing signs identifying used oil recycling collection sites
- recognizing and rewarding exemplary used oil recycling efforts
- creating and initiating a public service campaign.

Tell students that even though the statewide campaign to promote used oil recycling has been successful, they are going to take on the role of Public Information Director and create a campaign to promote awareness of used oil recycling in their school, town, or community. (*Note: You may assign students to work in teams as in the survey portion of this activity.*)

2. Explain to students that a public information campaign is an organized method for getting a specific message across to a specific group of people, your target audience. Both the message and the audience need to be clearly defined.

The first element in producing a campaign is formulating a message.

An example of a message statement concerning used oil is:

Message: Recycle Oil

Sub-messages: recycling is easy
used oil can be dangerous
used oil harms the environment
recycling is good

Students need to create their own message and sub-messages to use in their campaigns, these should be based on the information collected in their research surveys. Other messages may include saving valuable resources, creating energy from waste, protecting our water, etc. Students may also choose to focus their message on misconceptions about how to handle used oil. (*See the chart in the Resource section that points to popular misuses of used oil.*)

The second element for students to address is deciding on a target audience.

Tell students that research done in several states has shown that the typical do-it-yourselfer oil changer is a male between 16 and 45 years of age. People older than 45 typically have their oil changed for them at service stations, repair shops, or commercial quick lube locations.

This does not mean that students should limit themselves to these audiences. Students may decide to create campaigns targeted at smaller subgroups, such as women drivers, or those under 16 who will be driving soon and may become do-it-yourselfers. Students may want to use the target population of their survey if they specified one.

3. Tell students to emphasize local oil recycling by including in their campaign information about where to recycle oil in your area. Students will need to designate a specific campaign area for this. They may select their school, neighborhood, city, or county.

4. Next students will want to consider the length of the campaign and the best season for launching their campaign. You may remind students that more do-it-yourselfers change their oil in the spring and summer months and in early fall than in the winter.

5. Allow students several weeks to research and complete their campaigns. Encourage students to use more than one public information tool. Review these tools with the class:

- **Public Service Announcements** - nonpaid commercials that broadcast stations run for nonprofit causes as a community service. Students would specify their choice of local radio and television. These announcements can be scripted or produced on audio and/or video tape. **Public Service Interviews** - guest appearances on local talk shows on radio or television. **Public Service ads** - print ads that are run for no cost. Students would produce samples for local newspapers, yearbooks, magazines etc.

- **Press Kits** - a folder containing information for the press such as background information, brochures, charts, graphs, photos, logo art, quotes from experts, etc. **Press Releases** - written news information given to the press for release in the paper.

- **Direct Mail** - printed letters and/or post cards mailed directly to homes and businesses. If you select direct mail have a plan for whom you will mail to, what your direct mail will say, and how to pay for postage.

- **Brochures** - information booklets that may be as simple as a single sheet flyer or as complex as a multi-page magazine. Have students produce the design and copy - what the brochure will look like and what it will say - and a plan for how these will physically get to their audience.

- **Billboards and posters** - highway or streetside billboards or posters for store fronts. Have students produce design samples.

- **Press Conference and Speeches** - prepared statements for the media and other audiences. These may be scripts or delivered as speeches in a mock press conference.

- **Point-of-Purchase Displays** - stand up displays used in stores or in lobbies.

- **Premiums** - anything that can serve as a reminder of the message which will appeal to the target audience (i.e., buttons, bumper stickers, coffee mugs, pencils, key rings, T-shirts, etc. Encourage students to use their imagination if they decide to include premiums as part of their campaign.

- **Envelope stuffers** - community service notes that may be included in monthly utility or telephone bills.

- **Other.** As audiences and lifestyles change, the way they are reached will continue to change in response. Encourage students to think of new ways to reach their target audience with their message.

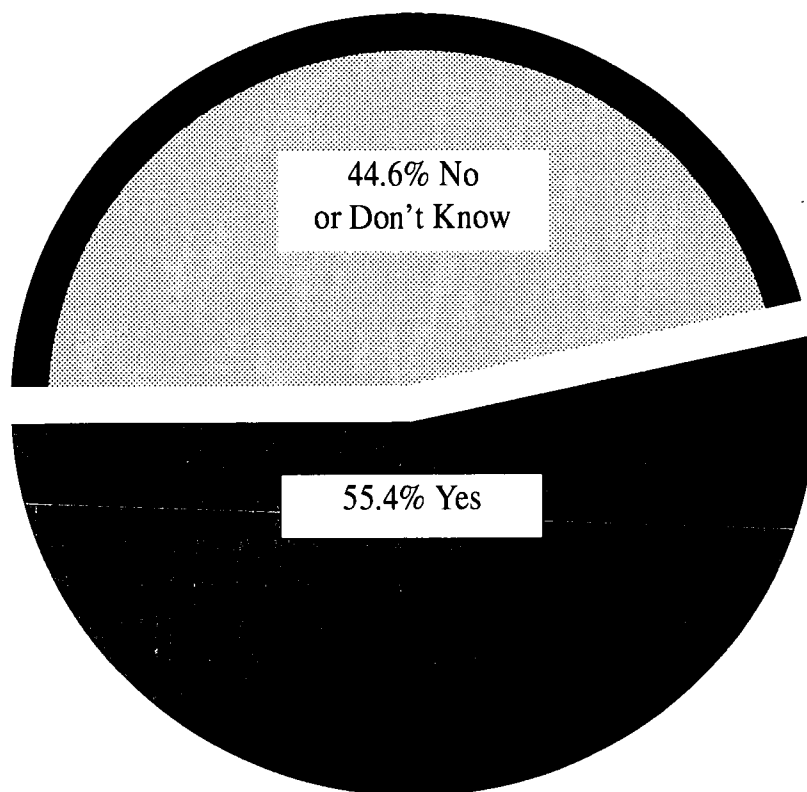
Remind students that in a real world situation they would be working with a limited *budget*. Students should weigh the effectiveness of their choices against the cost. For example, while it might be nice to give a T-shirt to every one in the county to remind them to recycle their oil, it would not be practical.

6. Schedule student teams to present their campaigns to the class or to a panel of judges you select. You may want to limit presentation times to 20 minutes per team.

Advise students that presentations will be judged on how *effectively* they reach their defined target audience with their defined message, how well their campaign is designed (the quality of the writing and visuals), and the comprehensiveness of the strategy employed (Did they use several tools? Was the message consistent?). You may want to establish a minimum criteria.

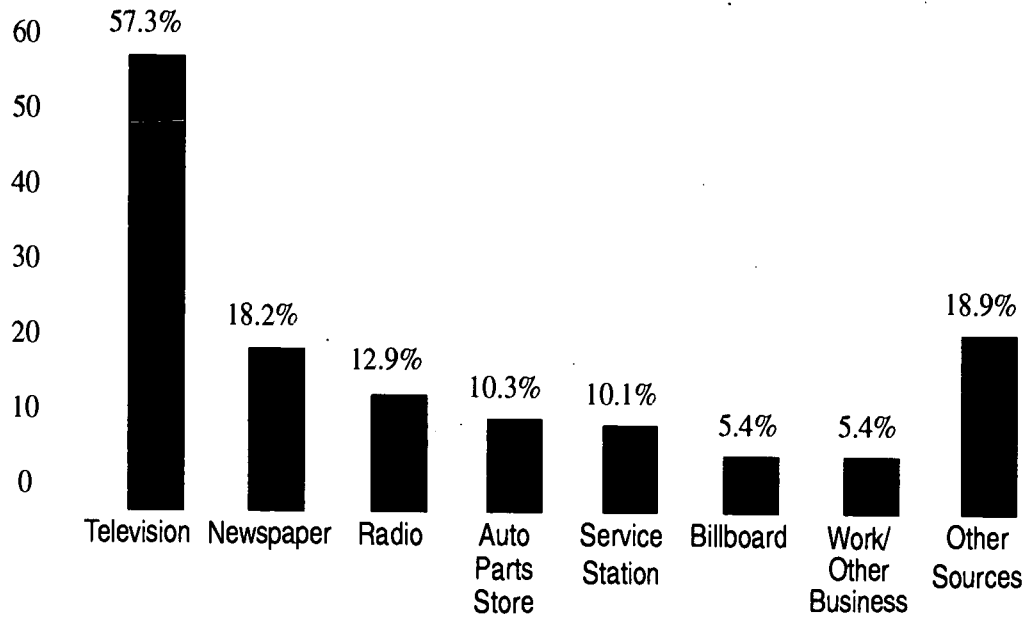
7. Award the winning team and display their work for other students to see. You may also coordinate displaying student work at local shopping malls or at automotive dealerships in town. Professionals from local newspapers or television or radio stations, or from local advertising agencies may be interested in participating as student advisors, or may be willing to serve as judges.

SEEN OR HEARD PROMOTIONS ABOUT
RECYCLING USED MOTOR OIL



Source: 1993 South Carolina Used Oil Partnership Survey

WHERE SEEN OR HEARD OIL RECYCLING PROMOTION
(% OF THOSE WHO WERE AWARE OF PROMOTION)



Source: 1993 South Carolina Used Oil Partnership Survey

SEEN OR HEARD ANY ADVERTISEMENTS OR PROMOTIONS ABOUT OIL RECYCLING IN THE LAST YEAR BY DEMOGRAPHIC CHARACTERISTICS

	Yes	No	Don't Know	Numbers
Totals	55.4	42.7	1.9	829
<u>Sex</u>				
Male	65.3	33.7	1.1	390
Female	46.9	50.5	2.6	435
<u>Race</u>				
Black	45.6	52.7	1.7	222
White	59.9	38.1	2.0	587
<u>Age</u>				
18 - 29	48.9	51.1	0.0	223
30 - 45	65.6	33.5	0.9	275
46 - 64	56.4	40.1	3.5	190
65 and older	46.9	47.9	5.2	121
<u>Education</u>				
Less than High School	43.6	51.5	4.9	135
High School Diploma	47.8	51.7	0.5	268
Some College	61.5	37.1	1.4	238
College Degree	69.7	27.9	2.4	175
<u>Income</u>				
Under \$15,000	42.4	52.3	5.2	109
\$15,000 - \$29,999	53.2	45.8	1.0	171
\$30,000 - \$49,999	60.8	37.5	1.6	232
\$50,000 - over	68.9	30.1	1.0	171
<u>Area</u>				
Urban	53.4	44.0	2.7	222
Suburban	59.0	40.1	1.0	258
Rural	55.3	42.6	2.1	334
<u>Region</u>				
Upcountry	51.9	46.5	1.7	339
Midlands	56.4	41.9	1.7	257
Lowcountry	59.2	38.4	2.4	220

Source: 1993 South Carolina Used Oil Partnership Survey

News Release

FOR IMMEDIATE RELEASE

May 20, 1992

COLUMBIA - New laws regulating the disposal of used motor oil and old car batteries in South Carolina go into effect May 27, the S. C. Department of Health and Environmental Control announced today.

"This means that you can't pour used oil on the ground, in streams, storm drains and sewers or dispose of it at a municipal solid waste landfill," said William W. Culler, director of DHEC's Division of Solid Waste Management. "Batteries are also banned from landfills. Used oil and batteries must be taken to recycling centers."

The improper disposal of used oil is a serious threat to the environment. It is estimated that more than 1 million gallons of used oil is improperly disposed of in South Carolina each year by do-it-yourselfers, people who change oil in their vehicles.

The South Carolina Used Oil Partnership, a public-private partnership to promote public awareness about the proper disposal of used oil, has been established by DHEC's Office of Solid Waste Reduction and Recycling.

The partnership is comprised of DHEC; Santee Cooper, the state-owned electric utility; the S.C. Department of Highways and Public Transportation; and the S.C. Petroleum Council. The Council represents the petroleum industry in the state.

In July 1990, Santee Cooper began its Give Oil For Energy For Energy Recovery c Gofer Program. This effort to collect used oil from do-it-yourselfers has expanded statewide and now has 83 sites in 19 counties. By 1994, there will be an average of five GOFER sites in each county.

Do-it-yourselfers can comply with the used oil law by taking their oil to a GOFER site, commonly located at a county or municipal recycling center. For the location of the GOFER site nearest you, call 1-800-753-2233.

In counties where no GOFER sites are located, do-it-yourselfers can take their used oil to collection centers set up by the S.C. Department of Highways and Public Transportation. In addition, several counties have set up collection centers.

Do-it-yourselfers also can check with area auto parts stores, service stations and commercial businesses to see if they accept used oil.

Retailers are required to take old batteries when a consumer buys a new one. If a consumer doesn't return an old battery when buying a new one, a \$5 deposit will be charged. The deposit will be given back when the used battery is returned.

The bans are the first to take effect under the S.C. Solid Waste Policy and Management Act of 1991. Anyone who disposes of used oil at a landfill is subject to a \$200 fine.

####

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South Carolina
Department of Health
and
Environmental Control

Office of External Affairs
2600 Bull Street
Columbia, S.C. 29201
(803) 734-5038

Slippin' Up On Used Oil

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 6 – 12

Focus: Debating what to do with used oil

Subjects: Social Studies, English, Drama

Materials: Handouts included with this lesson

Teaching Time: One class period



Learning Objective

Students will:

- look at prevailing misconceptions about what to do with used oil
- examine options to trashing used oil.

In this lesson students will role play fictitious characters as they present their ideas about what to do with a container of used motor oil. The group will debate their positions and will help the local boy, John Dear, decide what to do with his container of used motor oil. Character cards with this lesson will guide students through their roles.


Background

For background information on used motor oil and proper disposal methods, see the Resource section of this lesson package.

It is also helpful to identify local used motor oil recycling sites and to have this information available to share with the class after the lesson has been discussed. If you are unable to locate used oil recycling sites in your area, call the South Carolina Department of Health and Environmental Control, toll free, 1 800 SO USE IT.

Learning Procedure

1. Review with the class the information in the Resource section on recycling used oil. Have students discuss their experience with changing oil or watching someone else change the oil in a car, lawn mower, or other engine.
2. Tell students that they are going to role play the decision-making process for dealing with a common used oil disposal situation. Divide the class into groups of 12 students for this role playing exercise. Remind students that there are many different views on what to do with used motor oil. Use the Character cards with this lesson to assign roles. *(Note to teachers: it is very effective with role playing exercises to have students "get into costume" for their roles. You may bring appropriate props or assign students to bring in or make their own costumes.)*



According to government statistics, most do-it-yourself oil changers do one of two things with their used oil: they either dump it down the drain or throw it in the trash.

Source: *The Green Consumer*

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3. Each student should get one card listing a possible reaction or opinion to the question raised in the scenario, that is, *What should John Dear do with his jug of used motor oil?* Students are to represent the point of view presented on the character card in a group discussion. For example, if a student is Officer Inferno, that student should represent the views that storing the oil and oily rags is dangerous. Students should be encouraged to study and then ad lib their characters. This exercise should produce a lively discussion.

Point out to students that while there are new laws and new solutions to the used oil problem, there are many people who do not understand the problem and have long-held misconceptions that need to be understood and corrected.

4. Allow each group about 30 minutes for discussion. Assign a reporter (someone not assigned a role to play) to each group to keep track of the discussion so that a brief oral summary can be made at the end of the discussion. (Depending upon how many students you have in the class, you may have these reporters report back to the class as a whole after the exercise is finished. If just one discussion group is used, then the reporter can jot down important ideas and can keep the discussion going.)

5. Begin the discussion by having each person briefly introduce his or her character. When students are in costume, this works especially well as an ice-breaking exercise to get the discussion going. After brief introductions, begin the discussion with John Dear as he explains his problem of what to do with his used motor oil. It is helpful to have the reporter assigned to keep the discussion going by calling on new speakers if there is a lull and by cutting off excessively long-winded characters. This exercise works well with participants standing, allowing for a very animated and informal exchange. Participants should be encouraged to speak up, and they should not be required to raise hands or to speak in any particular order.

Extension Activity

To learn more about used oil recycling have the class write a letter to the South Carolina Petroleum Council, a division of the American Petroleum Institute.

South Carolina Petroleum Council
Suite 250 The Textile Building
1340 Bull Street
Columbia, South Carolina 29201

(803) 799-9588, fax (803) 765-1512

Or call the South Carolina Department of Health and Environmental Control 1 800 SO USE IT.

CHARACTER CARDS: SLIPPIN' UP ON USED MOTOR OIL

JOHN DEAR

You are John Dear, a local boy. You cut lawns on the weekend. You have a jug of used oil from changing the oil in your Dad's large riding mower and don't know what to do with it. In fact, you have several jugs of this used oil piled up in the garage from your new business and your Dad says, "get rid of it, NOW!"

OFFICER DO-RIGHT

You are Officer Do-Right, a police officer. You don't know what to do with the oil but you do know that it is illegal to pour it on the ground or in the storm drain.

You are also John Dear's dad. You want the garage cleaned out today!

MR. IT'S NOT MY PROBLEM

You are Mr. It's Not My Problem. You drive a car that burns oil and drips oil. You say it can't hurt anything cause you've been driving like this for years. You don't change your oil, you just let it burn down and add more. You say this also saves money.

John Dear cuts your lawn and you think he should stop spending time and money changing the oil in the mower and lower prices.

MR. GREEN JEANS

You are Mr. Green Jeans, a farmer. You say used oil from trucks and tractors is great for pouring on the dirt road to settle dust. You do this a lot in the summer when it doesn't rain much. You say that you'll be glad take John Dear's extra oil off his hands.

MISS DAISY

You are Miss Daisy, a gardener. You pour your husband's used oil on weeds and on the pond behind the house to kill mosquitoes. You say it works great and can't possibly hurt anything because it's what your family has always done. Besides, you grow the biggest tomatoes anywhere in the county and, of course, you know what you're doing.

OFFICER INFERNO

You are Officer Inferno, a firefighter. You say storing jugs of used oil and oily rags is a fire hazard and burning used motor oil is dangerous. You say that those jugs of oil have to be out of John Dear's garage immediately.

MS. BUSYBODY

You are Ms. BusyBody, a neighbor. You sometimes smell oil in front of your house near the storm drain. You are on the lookout to find out who is pouring their oil there. You think the oil should be put in the trash can cause "they" will know what to do with it.

HOT-ROD

You are Hot-Rod, Ms. BusyBody's son. You love cars, change your oil every 3,000 miles without fail and pour the oil in the storm drain in front of the house when your Mom isn't looking. You think that it is too much trouble to worry about what to do with a little oil. Besides, you kinda like the smell.

MIKE THE MECHANIC

You are Mike, the local Mechanic. You are interested in setting aside space at your shop for used oil recycling site. By law, you must collect all the oil from your oil changes and dispose of it properly. You recycle this used oil by contracting with an approved, registered used oil hauler that picks it up and takes it to an energy recovery facility. A lot of people in town would rather save a few bucks and change their oil at home. You know that much of this oil is dumped out all over town and are worried about its effect on the environment.

UNCLE JOE

You are Uncle Joe, who runs a fix-it shop. You are the local expert on everything, and you say that it is a free country and you think all this recycling is just a lot of hype. You hose the used oil that drips and pours from your small motor repairs off the floor and out into the street. You say used motor oil can't hurt a thing.

LEN THE LANDFILL OPERATOR

You are Len, the local landfill operator. You say used oil does not belong in the local landfill, in fact, it is banned from disposal in the landfill. If you put used oil in the trash it can still cause pollution because the local landfill doesn't stop liquid from seeping into the ground.

GONE FISHIN'

You are Gone Fishin', a local catfish catching expert. You say that even a little used motor oil can ruin the local streams and ponds. You think that used motor oil contains all kinds of contaminants and you're worried that one day your champion fish won't be worth frying.

You think that John Dear should just dump all his used oil in a big barrel and burn it or rub it on his dog to prevent mange.

What Is This Stuff?

9.Air.9

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 - 10

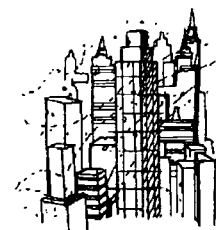
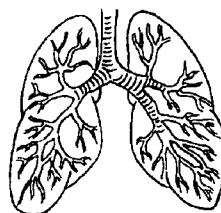
Focus: Air Pollutants and Their Sources

Subject: Environmental Science, Biology

Materials: Student work sheets

Teaching Time: Two class periods

Vocabulary: ambient, pollutant



Learning Objective

Students will:

- investigate six major pollutants including major sources and effects
- list ways to reduce air pollution.

Background

See the Resource section for information and ideas on things you can do at home to reduce air pollution and conserve our resources.

The U.S. Environmental Protection Agency sets air quality standards so that even people who are the most sensitive to air pollution, usually the very young, old, or sick, do not suffer adverse health effects from air pollution. The National Ambient Air Quality Standards were set for substances identified as "criteria pollutants," common, widespread pollutants shown by research to be harmful to human health and to general public welfare. "Welfare" includes crops, livestock, vegetation, buildings and visibility. **Ambient** means the air around us.

Carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter, and sulfur dioxide are the criteria pollutants.

Many efforts are underway to reduce air pollution. Air pollution control devices are being installed in factories, power plants, vehicles, and even wood-burning stoves to trap pollutants before they get into the air. Using cleaner burning fuels and more advanced combustion technology help reduce pollution. Other efforts include encouraging people to use cars less and to conserve electricity. This will reduce the amount of fuel we burn and, at the same time, reduce the amount of pollutants we put into the atmosphere.

Learning Procedure

1. Remind students that the atmosphere is necessary for plants, animals and humans to live. The atmosphere is only a thin layer of air, roughly comparable to the skin of an apple. Natural air pollution caused by volcanoes and forest fires has always existed. Naturally produced pollutants are present in greater amounts than pollutants from human origin. Because they are less concentrated and, in many cases, less toxic than pollutants resulting from human activities, natural pollutants

DOWN TO EARTH

DATELINE: JANUARY 1, 1992. UTAH COUNTY, UTAH: According to the *Salt Lake City News*, doctors claim about 50 Utah County residents die each year because of air pollution.

The Information Please Environmental Almanac, 1993

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do not present as serious a problem as human-made pollutants do.

Modern society uses large quantities of fuel to produce electricity and power vehicles and also engages in industrial activity, all of which results in air pollution. Not only are some of these pollutants very harmful, but the activities producing them are often carried out in urban areas, increasing their concentration in places where many people live and work. We have no control over natural pollutants, but we can control human-made pollutants. As humans produce even more pollutants, control and reduction of them becomes increasingly important ... and difficult.

2. Introduce the term **pollutant** and identify air pollutants as chemical or materials that change the air so that its use is impaired in some way. Tell the students that many air pollutants come from burning coal, oil, wood, and other fuels. We use these fuels to run factories, cars, and power plants that generate the electricity that heats and lights our homes. Other pollutants come from industrial and manufacturing processes. These are typically released in much smaller quantities but are generally much more toxic. Regardless of their source, these pollutants are a byproduct of today's lifestyle ... a lifestyle that we enjoy and expect. Totally eliminating these pollutants would require drastic changes in lifestyle ... changes most of us would rather not make.

Ask the students to name any air pollutants, natural or human-made.

3. Present the following information on each of the six major pollutants. Remind them that these are "criteria pollutants" and are regulated at the federal level by the EPA. The following descriptions are from the US EPA.

Carbon monoxide: A colorless, odorless gas emitted when vehicles burn fuel. It is also given off by kerosene or wood stoves used to heat homes. The effects of carbon monoxide include headaches, reduced mental alertness, and heart damage. It may even cause death by reducing the oxygen-carrying capacity of red blood cells.

Lead: Formerly a problem when all cars used gasoline with lead additives. When leaded gasoline is burned, lead is released into the air. Some industrial processes also result in lead air pollution. When people or animals breathe lead over a period of time, it accumulates in their bodies and can cause brain or kidney damage. Today most cars use unleaded gasoline, and the use of lead additives has been phased out in South Carolina.

Nitrogen Dioxide: Is a light brown gas at low concentrations. In higher concentrations it becomes a major component of brown urban haze. Nitrogen dioxide is the result of burning fuels from utilities, industrial boilers, cars, and trucks. It is one of the major pollutants that causes smog and acid rain. In high concentrations, it can harm people and vegetation. In children it may cause increases in respiratory illness such as chest colds and coughing. Asthmatics may suffer from more difficult breathing.

Particulate Matter: Soot, dust, tiny droplets of liquid, and other materials. It is sent into the air usually by burning coal, diesel fuel, or wood. Particulates gradually settle back to the earth and can cause people to cough, get sore throats or develop more serious breathing problems. They can affect animals and plants. The smaller the particulates, the more easily they can travel deep into the lungs, causing more harm.

Sulfur Dioxide: Emitted by power plants and factories that burn coal for fuel. Sulfur dioxide is the main sulfur oxide pollutant. It can harm human and animal lungs, as well as all kinds of plants. Sulfur dioxide is a main contributor to acid rain. It reacts with oxygen in the air to become sulfur trioxide which then reacts with water in the air to form sulfuric acid. Acid rain can harm animal populations in lakes and rivers as well as trees and plants by damaging leaves and root systems. It can deteriorate metal and stone on buildings and statues. Acid-forming dry particles can also fall to earth. The effects of acid rain are not only local, they can also occur hundreds of miles away from their source.

4. Give each student a copy of the work sheet (included). Have the students complete the sheet by selecting the correct sources and effects from the information provided above. (The answers are as follows:

Carbon monoxide: Sources: cars, wood stoves; Effects: less oxygen in blood, reduced mental alertness, heart damage.

Lead: Sources: coal-fired electric power plants, metal refineries, lead consuming industries such as battery manufacturers; Effects: brain damage, contaminated crops and livestock that then introduce lead into our food chain.

Nitrogen Dioxides: Sources: cars, coal-burning stoves, coal-fired electric power plants; Effects: lung damage, damaged forests, smog.

Ozone: Source: vehicles (formed mainly from pollutants in exhaust), other sources of ozone-forming fumes such as gas stations, paints; Effects: eye irritation, respiratory tract problems, lung damage, damaged vegetation, smog.

Particulate Matter: Sources: diesel engines, windblown dust, wood stoves; Effects: lung damage, eye irritation, reduced visibility, discolored buildings and statues.

Sulfur Dioxide: Sources: coal-burning electric power plants, coal-burning stoves, refineries; Effects: eye irritation, lung damage, harmed aquatic organisms, damaged forests, deteriorated buildings and statues. (These effects are largely due to acid rain.)

Extension Activities

1. Write to the U.S. EPA and DHEC to request information on major air quality legislation, including major changes in recent years.
2. Invite a representative from a local power plant to discuss air pollution control efforts and how they have changed in the past 10 years.
3. Research what air pollutants South Carolina industries release and how are they monitored.

4. Research the “killer smog” in London in December 1952 that resulted in the deaths of more than 4,000 people.

5. Trading Emission Credits: In March 1993, the U.S. EPA created a system that allows the nation’s 110 worst polluting power plants in 21 states to buy, sell or trade unused sulfur dioxide emission credits. The EPA created the system in an attempt to encourage utilities to invest in better anti-pollution equipment. The long-range goal of the program is to cut acid rain in half by the year 2010. The EPA issues credits that are based on the power plant’s size. For example, if a corporation is assigned 10,000 credits, it can legitimately release 10,000 tons of sulfur dioxide into the atmosphere annually. If this plant has purchased the latest anti-pollution equipment and it releases only 6,000 tons, the company still has 4,000 credits. These credits can then be sold to another utility to help it recover its costs for the purchase of the new equipment.

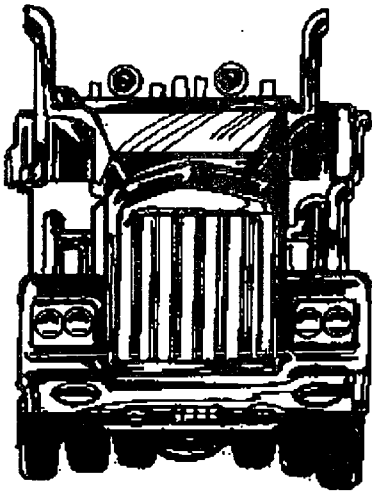
Ask: Why are utilities big contributors to acid rain? What causes this form of pollution? What is the EPA’s reasoning behind the creation of this long-term program? How can power companies reduce the level of sulfur dioxide they release into the atmosphere? Environmental activist organizations opposed this program from the very beginning. Since it appears to be a step in the right direction, why would these organizations be opposed to trading emission credits? Why would the EPA allow the trading of pollution credits on a stock exchange? Some environmental groups are buying these publically traded credits and talking them “out of circulation.” What do you think about that practice?

Just Do It

Concentrations of some toxic and cancer-causing pollutants can be as much as 100 times greater indoors than outdoors. Open the windows once in a while to let some fresh air breeze through the house ... and your classroom.

Particulate Matter

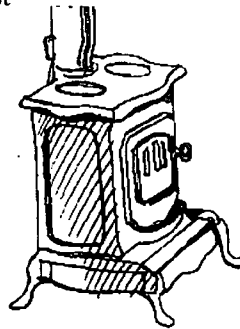
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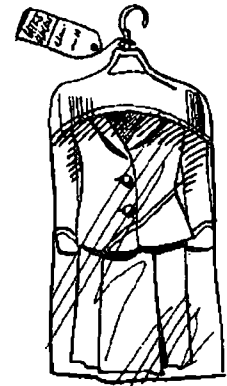
Diesel Engines



Windblown Dust

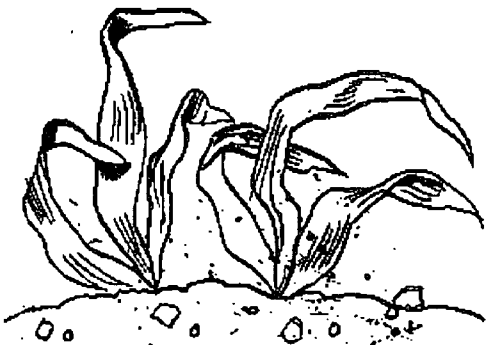


Wood-burning Stoves



Dry Cleaners

Effects:



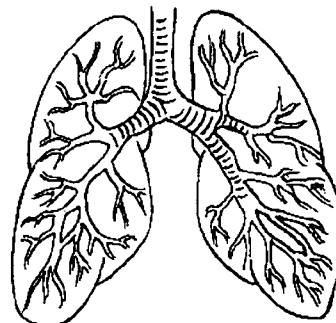
Damaged Crops



Brain Damage



Reduced Visibility



Lung Damage



Corroded
Buildings, Statues



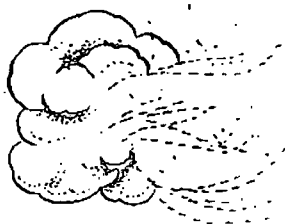
Eye Irritation

Carbon Monoxide

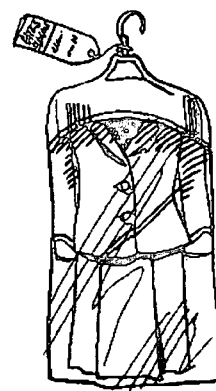
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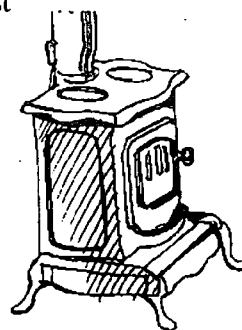
Cars



Windblown Dust



Dry Cleaners

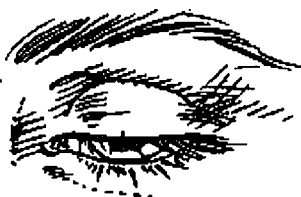


Wood-burning Stoves

Effects:



Corroded
Buildings, Statues



Reduced Mental
Alertness



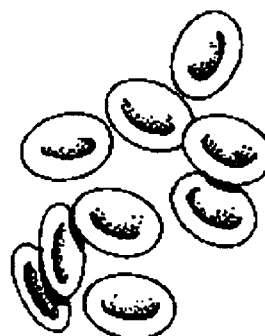
Heart Damage



Global Warming



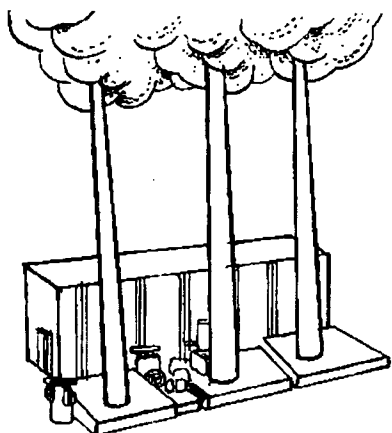
Smog



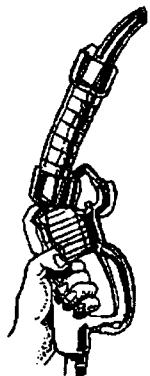
Less Oxygen in Blood

Lead

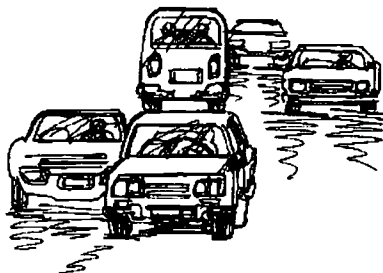
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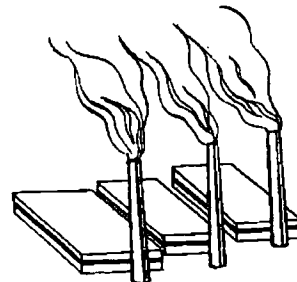
Electric Power Plants



Leaded Gas

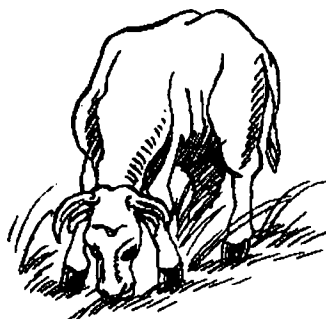


Cars



Metal Refineries

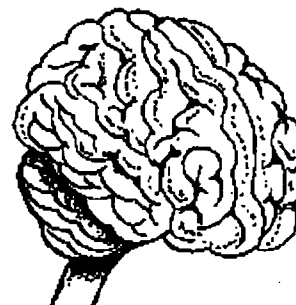
Effects:



Contaminated Livestock



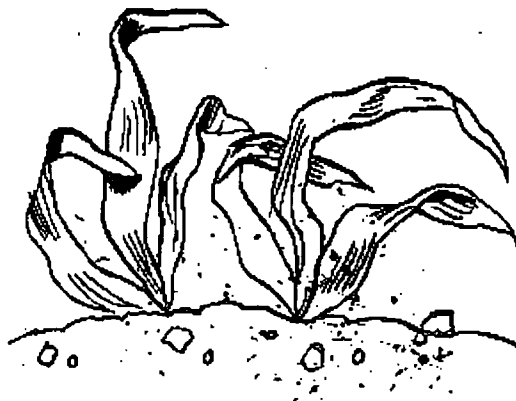
Smog



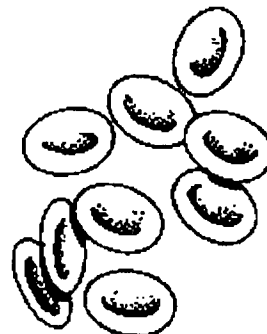
Brain Damage



Eye Irritation



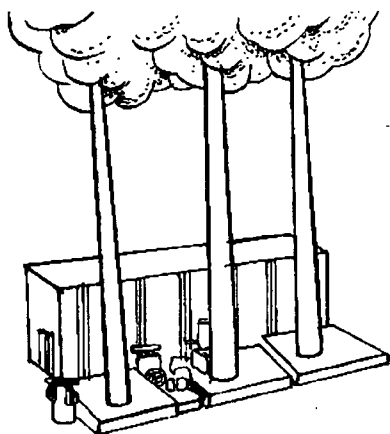
Contaminated Crops



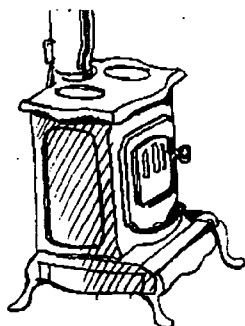
Less Oxygen in Blood

Nitrogen Oxide

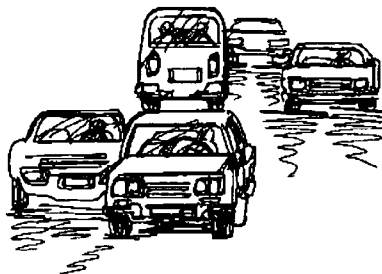
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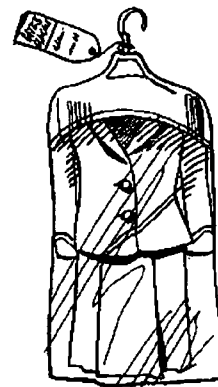
Electric Power Plants



Wood-burning Stoves



Cars



Dry Cleaners

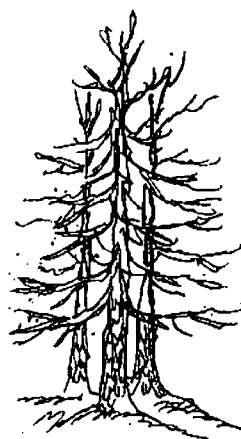
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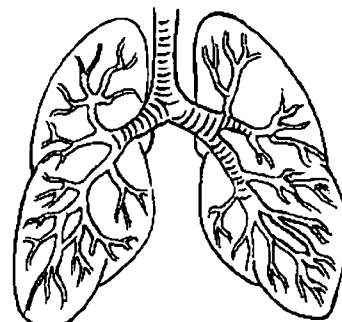
Corroded
Buildings, Statues



Smog



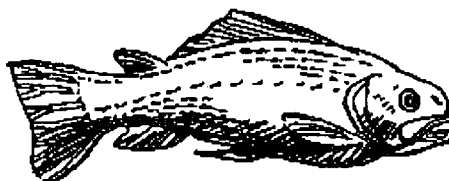
Damaged Forests



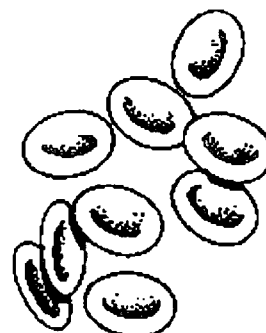
Lung Damage



Eye Irritation



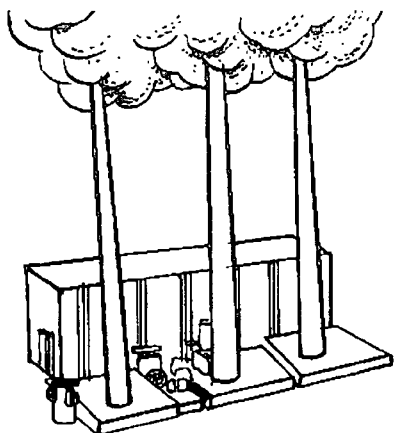
Dead Aquatic Life



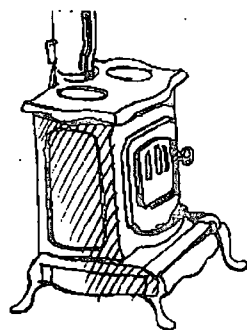
Less Oxygen in Blood

Ozone

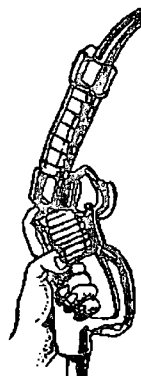
Sources:



Electric Power Plants



Wood-burning Stoves

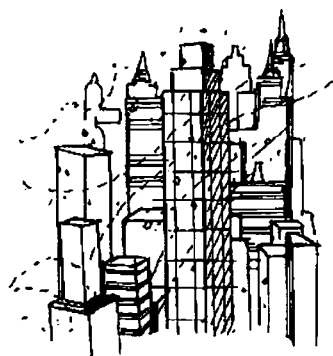


Leaded Gas



Cars

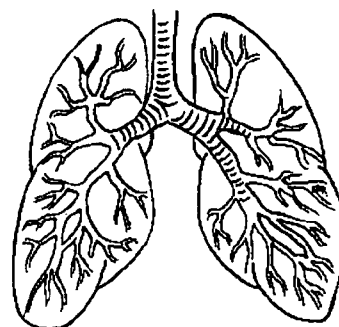
Effects:



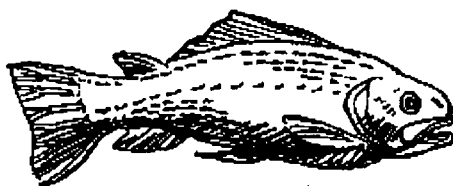
Smog



Respiratory Tract Problems



Lung Damage



Dead Aquatic Life



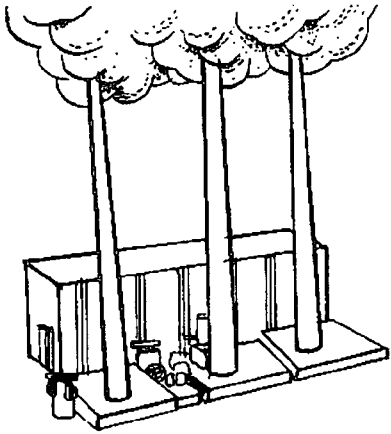
Eye Irritation



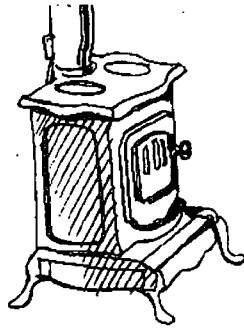
Contaminated Crops

Sulfur Dioxide

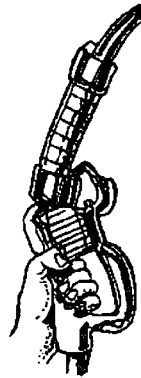
Sources:



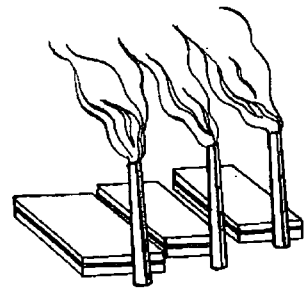
Electric Power Plants



Wood-burning Stoves



Leaded Gas



Coal-fired Industrial Boilers

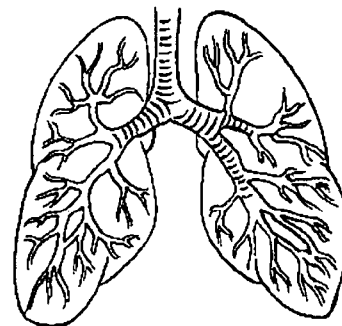
Effects:



Smog



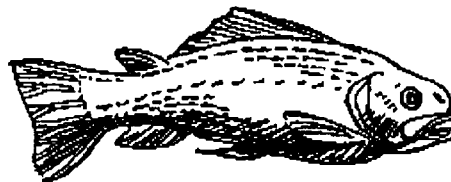
Corroded Buildings, Statues



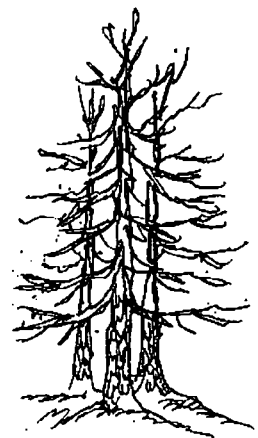
Lung Damage




Eye Irritation



Dead Aquatic Life



Damaged Forests



Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

For more information about South Carolina and the environment, call the
South Carolina Department of Health and Environmental Control at
1-800-768-7348.

Who's in Charge Here?

9.Air.10

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 - 10

Focus: Environmental Watchdogs

Subject: Science, Government, Social Studies

Materials: Transparency *Timeline*

Teaching Time: One class period, out of class research



Learning Objective

Students will:

- research the history of environmental regulations in the United States and their historical context
- research environmental regulatory and enforcement agencies on both the national and state level.

Background

The 1970 Clean Air Act set a 1975 deadline for eliminating 90 percent of all automobile emissions, established the U.S. Environmental Protection Agency (EPA). Also introduced in 1970 was the Resource Recovery Act and the concept of resource recovery as an alternative to land disposal. This was major environmental legislation. However, the U.S. passed its earliest environmental laws in 1948, the Water Pollution Control Act. By this time, the Industrial Age had been in full swing for nearly 75 years.

2. Have the students research and report on the formation and responsibilities for the US EPA and the S.C. Department of Health and Environmental Control. Your County Library is an excellent source for this material. The various divisions of DHEC produce annual reports and many are available in libraries across the state. Have students find out the difference between regulations and enforcement, who makes environmental laws, why environmental laws are made, have environmental laws changed over the years and why?

Learning Procedure

1. Show the transparency, *Timeline*, and discuss some of the technological advancements and environmental laws.

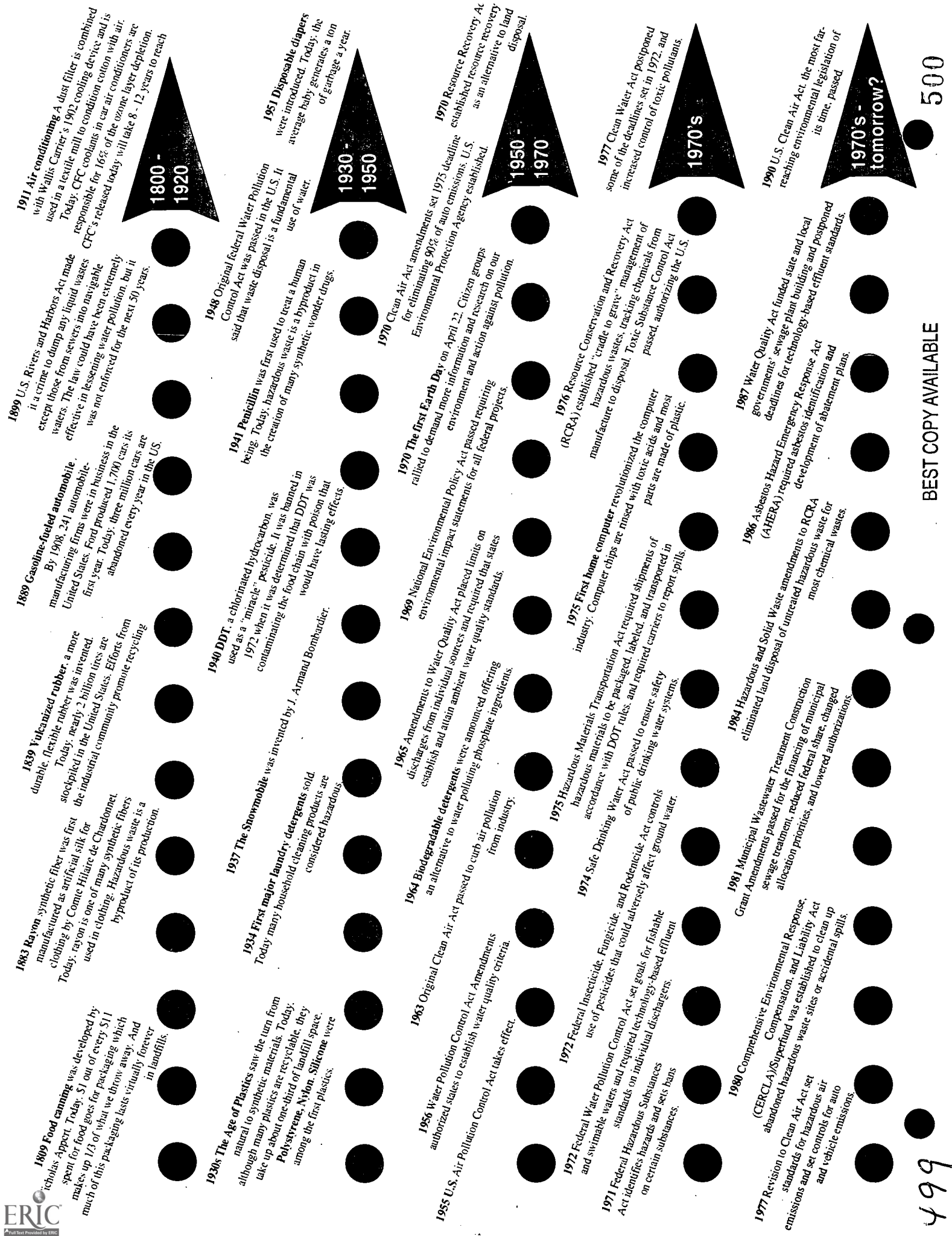
To help students' with their investigations, they can call the the DHEC Resource Center in Columbia at 1-800-SO-USE-IT.



The use of catalytic converters in automobiles has reduced emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds in the United States, Canada, and Japan. These, however, are just beginning to come into use in Europe.

The Information Please Environmental Almanac, 1992

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Chemicals in Groundwater

9.nps.1

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 - 12

Focus: Understanding how chemicals travel from land to water and the effects.

Subject: Science, Biology

Materials: LaMotte Test Kit for Nitrates and Phosphates or similar, surface water samples, containers for water, fertilizers such as ammonium nitrate or sodium nitrate

Teaching Time: Several class periods

Vocabulary: Groundwater, surface water, pollution, nitrates, algae bloom

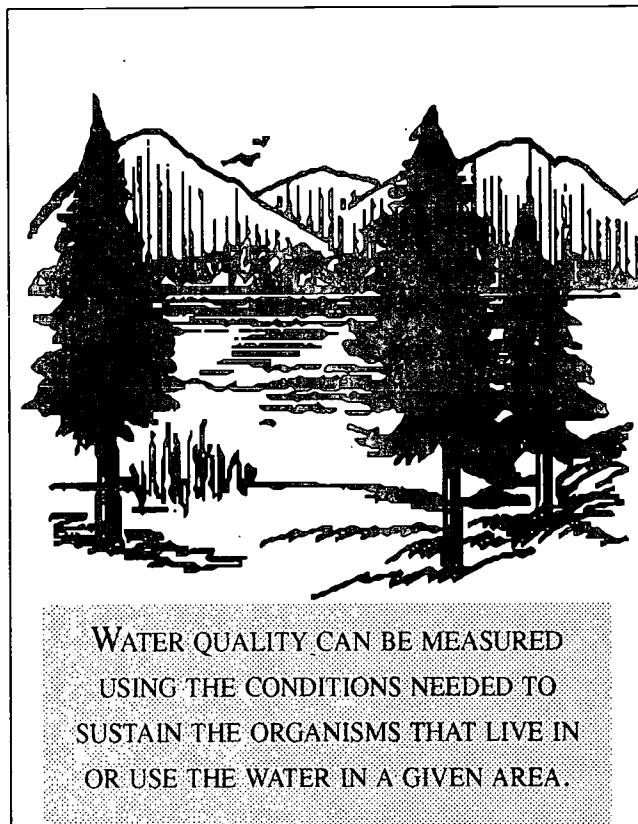
Learning Objectives

In this activity, students will analyze water samples for nitrates and test the affects of nitrates on water samples. Students will:

- see how nitrates move from land to water
- see how water/runoff and pollution can affect water quality
- review the sources of nitrates.

Background

As water molecules in the water cycle evaporate and return to the atmosphere, they leave behind salts and other materials found in water. As this "cleansed water" returns to the earth through the atmosphere in the form of precipitation, various impurities in the air are intercepted. When it reaches the ground, water again contains both manmade and natural impurities, such as carbon dioxide, dust and pollen. As the water runs its course on the land, it continues to collect or dissolve and carry oxygen, nutrients, minerals, nitrates, phosphates, carbon dioxide and other materials, most of which are necessary for the life of animals and plants. The types and amounts of



materials vary according to the location's geology, topography, vegetation, soil type, weather, water velocity, and land use. Eventually, these collected materials are deposited in various parts of the water cycle before the water re-enters the atmosphere and continues to be recycled.

Water quality can be measured using the conditions needed to sustain the organisms that live in or use the water in a given area. If alteration and use of the land lowers these conditions to certain levels, the water is considered polluted.

Exactly where water travels and how quickly it moves also depend on various factors, such as an area's topography and vegetation, and its soil and



About 15 percent of Americans – 40 million people – rely on private wells, springs, or cisterns for water.

source: 1994 *Environmental Almanac*

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rock types. Precipitation falls into water or on land where it “runs off” of a hard surface such as rock or concrete, or infiltrates a soft surface such as soil or sand. If it moves downward, it can replenish water contained in the underground rock and sediment. This supply of water is referred to as “groundwater.” Water remaining on the surface enters local wetlands, ponds, streams, rivers and lakes.

An estuary is a special place where fresh water from the drainage basins mixes with saltwater from the ocean’s tides. It can include bays, marshes and tidal flats. These delicate areas produce diverse plant and animal life which consistently deal with changes in tide, temperature, salinity, and oxygen levels. The water flowing through South Carolina’s drainage basins comes into contact with a variety of land uses in rural, suburban, and urban areas, before emptying into an estuary. While a portion of the materials that collects in the water settles in such areas as ponds and lakes, the rest empties into the estuaries, earning them the nickname of “sink holes.” These materials may leave an estuary quickly to mix with ocean waters, or they can remain in estuarine waters for a long time, depending on the shape of the estuary and the rates in which waters entering and exiting it can flush them out.

Nonpoint source pollution, or NPS, is runoff water pollution that originates from many sources rather than one known point, such as an industrial discharge pipe or a tanker oil spill. This runoff pollution is any manmade or natural material carried by rainwater over land to enter storm drains, ditches, streams, rivers, estuaries, lakes, groundwater, and even the ocean itself, and thus becomes a part of the water cycle. This pollution may also come from manmade or natural materials dumped or emptied into the soil.

Examples of nonpoint source pollution include soil eroded from construction sites; fertilizers and pesticides from fields and lawns; metals and oil from automobiles; road salts; improperly discarded household hazardous waste; inadequate septic systems; animal waste from horses, cattle, waterfowl

and pets; and large amounts of grass clippings, leaves, and other natural debris. Manmade or natural materials, in small amounts, may not pose a threat to the environment. However, in amounts large enough to harm the organisms living in or using the water in a given area, these materials are pollution and degrade the quality of water.

In South Carolina, the problems associated with nonpoint source pollution statewide appear to be proportional to the state’s population density and distribution, and the intensity of local agricultural activity and other land uses.

South Carolina’s growing population of more than 3.5 million people is not equally distributed, with most people living near Columbia, Charleston, and the Greenville/Spartanburg area. It is in these more “active” regions that nonpoint source pollution amounts are prominent, though signs of it are found statewide. The growth of light industry, suburban expansion, and improved transportation corridors have exposed agricultural areas and vacant lands to development.

South Carolina’s more rural counties also suffer from various nonpoint source pollution symptoms from farming activities.

Also, waterfront properties continue to attract both homeowners and businesses alike, developing or redeveloping properties along lakes, rivers, estuaries and oceanfront. Although these people do not intend to cause pollution, the activities of residents in all of these areas and situations contribute to pollution sources and amounts.

Nonpoint source pollution has been identified as affecting water quality to some extent in all watersheds in the state. Under the authority of the federal Clean Water Act, state officials assessed South Carolina’s pollution and identified more than 336 waterbodies as nonpoint source pollution problem areas.

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At present, the full extent of nonpoint source pollution is not known in South Carolina. However, the SC Department of Health and Environmental Control has developed and is implementing control strategies through its education component and through the comprehensive watershed studies conducted in the East Cooper area and currently being implemented in the Gills Creek (Richland County) project area. These projects include surveys, studies and water monitoring, and citizen involvement. These, along with stronger management, the creation of new ordinances, public education and stronger participation at individual, municipal, county and state levels are the keys to the prevention of nonpoint source pollution.

Learning Procedure

1. Review with the class the background information on nonpoint source pollution and discuss the rural sources that contribute such as animal wastes and fertilizers.

2. Explain the natural sources of nitrates. (*fixation in atmosphere and fixation in soil contributing to nitrates*)

Since the atmosphere is 78 percent nitrogen (N_2) fixation is not uncommon during electrical storms where atmospheric oxygen (O_2) combines with the nitrogen to form a nitrogen-oxygen compound (NO_2). This compound then combines with rainwater to form nitric acid (HNO_3). The nitric acid reacts with soil minerals forming nitrates.

Nitrogen-fixing bacteria on legumes account for most natural soil nitrates.

3. Discuss manmade additions of nitrates. Additional nitrates are added to soil by farmers, since nitrates are essential for plant growth.

While waste from an animal feedlot may be considered natural, the concentrations of these wastes on recharge areas may lead to an excessive amount of nitrates in runoff from these areas.

Another manmade source of nitrates is septic tanks. It is estimated that 19.5 million septic tank systems put more

than 800 billion gallons of waste water into the ground each year. In recharge areas, this waste water may reach the aquifer, accounting for excess levels of nitrates.

4. Discuss the dangers of nitrates in drinking water. Nitrates are changed to poisonous nitrates in the human stomach. An excessive level of nitrates may cause methemoglobinemia in children less than 6 months of age (methemoglobinemia is a “blue baby” syndrome).

Nitrate levels of 10 ppm (parts per million) or greater are considered unsafe by U.S. Department of Health Service Drinking Water Standards.

5. Discuss the results of excessive nitrates in surface water. Nitrates tend to act in conjunction with phosphates to promote excessive growth of plants and algae. A vast growth of algae, called an algae bloom, makes the water look like pea soup. Also the death and subsequent decay of this life may deplete oxygen levels, making the water unsuitable for other aquatic life. Excessive enrichment of water with nutrients is called eutrophication.

Runoff is the major source of this pollution; excessive levels of nitrates in an aquifer would contribute to the problem.

6. Have the class perform this experiment on the effects of excessive nitrates on surface water.

Collect samples of water from various areas where nitrate contamination is likely to differ — for example, farm ponds vs. mountain streams. Or collect water from one source and add fertilizer to one sample while keeping the other as a control. In either case, the sample with the larger amount of nitrates should exhibit more rapid algae growth. Water that is very green or brown probably contains a high level of nutrients.

Determine concentrations of nitrates in water from various sources using a LaMotte Test Kit for Nitrates and Phosphates. These test kits are available from science supply companies and cost about \$30 for 50 tests. Please follow test instructions. Tests take several days to yield results.

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Remember, some nutrients should be there, it is the extra that we put in that's potentially harmful.

Extension Activities

1. After completion of this experiment, have students participate in these research activities:

- Explain the presence of natural nitrates in groundwater.
- Report on nitrogen fixation of legumes.
- Research the chemical reactions involved in converting atmospheric nitrogen to soil nitrates.
- Debate such things as animal feed lot location and limitation of use of fertilizers.
- Report on septic tank systems in terms of proper types for specific locations.
- Research methemoglobinemia.

2. Have students test for nutrient levels in water flowing into and out of a wetland. Is there a difference in the two tests? Why? (*Wetlands will filter and use up nutrients.*)

3. Total Suspended Solids in Water

In this activity, students will determine the total concentrations of suspended solids in a water sample.

Materials

- triple beam balance
- funnel
- filter paper (coffee filter works well)
- one-liter plastic soda bottle
- various samples (1 liter each) of water from local ponds, streams, etc.

Background

A lake with high productivity and fertility is said to be eutrophic. It has a greater abundance of materials than a lake with low productivity and fertility, an oligotrophic lake. To determine productivity, measurements are made of chlorophyll, total dissolved solids, conductivity, total suspended solids, turbidity.

The measurement of suspended materials in a body of water helps determine what the productivity, or ability to support life, of that water is. Suspended solids in water consist primarily of living and dead

phytoplankton and zooplankton, silt, animal wastes, some decaying plants and animals, and a wide range of treated human and industrial waste. The total suspended solids of a water sample is the amount of material, by weight, that is suspended (not dissolved) in a given volume of water.

Total suspended solids determinations include a variety of solids, which makes it difficult to set "acceptable standards." Wide deviations, sudden or even gradual, from locally established "norms" indicate problems. Values below the norm may be a sign of low productivity in the water. Values above the norm may point to excessive productivity.

Closely related to total suspended solids is a factor called turbidity. A turbidity reading measures the ability of a light beam to pass through the water sample. Water that has materials suspended in it scatters and absorbs light rays entering it, rather than transmitting the light in straight lines. Thus, a turbidity reading can give an indication of the total suspended solids. Turbidity in groundwater or surface water means that solids are in the water. These solids may include contaminants which could be harmful to human health. Therefore, keeping turbidity levels low is important for health reasons.

Learning Procedure

1. Collect 1 liter of water from each of a number of locations at your field site.

2. Weigh a filter paper.

3. Filter a 1 liter sample of water through the weighted filter paper. Allow the filter paper to dry completely.

4. Weigh the filter paper again. The change in weight is the weight of total suspended solids in 1 liter of water. Total suspended solids values are commonly expressed in mg per liter.

5. Check with the SC Department of Health and Environmental Control (GIVE NUMBER TO CALL) and ask for the established "norm" of total suspended solids for the body of water you are studying.

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Observations

1. Total suspended solids value of tested samples:

(List value for each sample located at various locations on field site.)

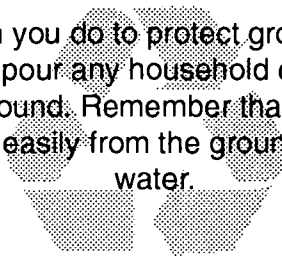
2. Local "norm" of total suspended solids = _____

3. Compare the values of tested samples and "norm."

4. What do test samples indicate about water's productivity? Is it high, excessively high, or low? Why? Explain your answer.

Just Do It

What can you do to protect groundwater?
Never pour any household chemical
on the ground. Remember that chemicals
travel easily from the ground to our
water.





Action

for a

cleaner tomorrow.

A South Carolina Environmental Curriculum

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1-800-768-7348.

Why Water Pollutes Easily

9.nps.2

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 - 12

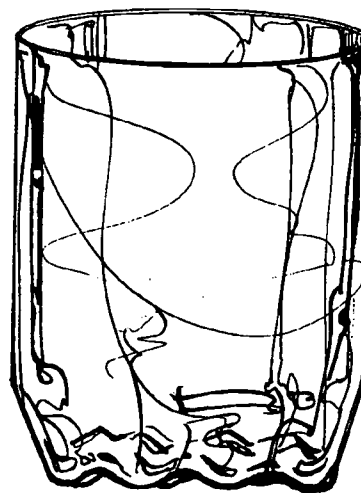
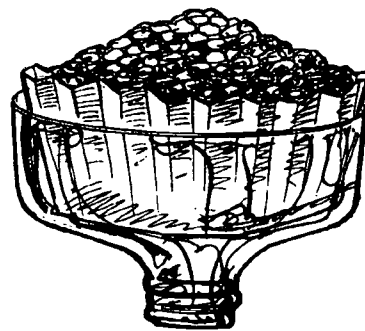
Focus: The atomic structure of water and why it pollutes so easily.

Subject: Science, Chemistry

Materials: See itemized list below

Teaching Time: One class period

Vocabulary: Solvent, hydrologist, pollution, pH, acids, bases, oxygen, hydrogen, covalent bond, salinity, dissolved oxygen, phosphates, nitrates, temperature, turbidity.



Learning Objective

Students will:

- examine the structure of water and causes/sources of pollution
- review the criteria for analyzing water quality
- see the basics of how natural and manufactured filtering systems work
- understand that some hazardous materials cannot be filtered by passing through soil.

In this activity students will study the properties of water and will perform experiments on what contaminates water.

Materials

One set of materials for demonstration, or one set for each student group.

- funnel (cut off top of soda bottle works)
- cheesecloth or coffee filter
- aquarium gravel or sand
- pH paper and/or pH meter/ litmus paper
- white vinegar (acid)
- 2 large beakers (or cut off 2 liter soda bottles)

Background

Chemically, water (H_2O) is composed of two hydrogen atoms that are covalently bonded to one oxygen atom. In a covalent bond, each atom shares its outer (valence) electron with the oxygen atom and vice versa. Oxygen atoms have a greater attraction for electrons than hydrogen atoms. As a result, the end of the molecule with the oxygen atom becomes negatively charged and the end with the hydrogen atoms becomes positively charged. Because the water molecule contains a positive and negative end, it is polar. This polarity results in an attraction of water molecules to one another and other polar substances. The negative oxygen end of

DOWN TO EARTH

In 1993, the Russian Federation reported that the former Soviet Union dumped into the seas vast amounts of highly radioactive waste. The threat to marine life is unclear.

source: 1994 *Environmental Almanac*

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a water molecule attracts the positive hydrogen end of another molecule forming a weak bond between water molecules. Since the weak bond involves hydrogen, it is called a hydrogen bond. The hydrogen bonding formed by water molecules is responsible for many of the unique properties of water.

Water the Universal Solvent

Because of its polarity, water is a universal solvent. It is able to dissolve most substances. Thus, water is rarely pure and is easily polluted.

As water runs off surfaces, it picks up pollutants because of its polarity. Water's polarity also makes it impossible to clean up polluted water completely.

Hydrologists estimate that between 2 and 10 percent of the nation's water is polluted. The major source of groundwater pollution is runoff – agricultural, urban streets, forestry, mining, construction, sewage, and non-agricultural fertilizers and pesticides.

Since water is capable of dissolving most substances it comes in contact with, its pH is influenced by the substance dissolved. If hydroxyl ions (OH^-) are produced, the water becomes basic, and if free hydrogen ions (H^+) are produced, the water becomes acidic.

The potential of hydrogen or pH is used to express the hydrogen ion in concentration in a solution. Substances that produce hydrogen ions are called acids, and substances that produce hydroxyl ions are called bases. The pH scale ranges from 0 to 14. The lower the pH value the greater the acidity. The pH scale is logarithmic, increasing 10 fold for each change in pH value. For example, a pH of 5 is 10 times more acidic than a pH of 6 and 100 times more acidic than a pH of 7. Solutions below pH 7 are acidic and solutions above pH 7 are basic.

Learning Procedure

1. Review with the class the basics of water's atomic structure and the background information with this lesson.

Ask: What is the difference between chemicals in solution and chemicals in suspension?

2. Work with the class to perform the following activity as a demonstration or in small groups. Put the coffee or cheesecloth filter in place at the bottom of the funnel. Fill the funnel with aquarium gravel.

3. Blend very small pieces of clean paper into a large beaker with 200 ml of water and then add 20 ml of the acid. Demonstrate the presence of acid using the pH paper.

4. Pour the mixture of suspended solids and acidic solution onto the gravel in the funnel. Drain the mixture into a clean beaker. Observe how the gravel filters out the suspended solids. Tell students that the aquarium gravel represents the soil or gravel under a landfill.

5. Test the liquid for acid. **Ask:** "Why is the acid still present? Does the water look clear? Is it pure? Would you want a local soft drink bottling plant to use this water in their product?"

If you use a pH meter, note whether there is any difference between the two readings. (This experiment can be performed by students.)

6. Discuss the differences between suspensions and solutions. Point out that suspensions contain larger particles in the water and that these particles can be trapped in the gravel, while chemicals in solution are so small that most are not filtered out by passing through gravel or soil.

That this is the case for some liquid hazardous wastes if dumped on the ground or poured down storm sewers or into septic tanks and

drain fields. For example, some household drain cleaners are more acidic than the solution in this demonstration. Explain that most landfills in the United States do not have liners to keep solutions of household hazardous waste and rainwater from migrating into the soil. (Note: New federal laws require all landfills to have liners and barriers and to meet strict requirements to minimize runoff and groundwater contamination.)

8. **Ask:** "What can you do at home to prevent harmful household products from contaminating groundwater?" (*Use less harmful products where possible, buy only the amounts of product you need to avoid storing, use products properly, dispose of containers as indicated on the labels.*)

Extension Activity

In this activity students observe and record how ponds and eventually groundwater become polluted from oil, chemicals, and detergents.

Materials

One set of materials for each student group.

- 8 pint jars (4 with tight-fitting lids)
- masking tape
- pencil or marker
- water
- funnel
- 1 tablespoon of cooking oil
- 1 tablespoon of vinegar
- 1 tablespoon of laundry detergent
- 1 cup of soil
- pH paper (optional)

Background

There are many ways that water becomes polluted. There is natural pollution from soil, leaves and tiny organisms that get into water from nearby land. Then, there is pollution caused by people. In farm areas, fertilizers and insecticides, and animal wastes get into streams and lakes. In industrial areas, harmful wastes are dumped into the water from factories and refineries. In cities and towns, sewage and runoff from streets and lawns find their way into water. This pollution, in turn, seeps into the groundwater which is where many people get their drinking water.

Learning Procedure

1. Follow these steps to make polluted pond water and to see what pollution can do to groundwater. Have students make a chart to record their observations.

2. Use masking tape to make a label for each jar and then label jars #1A, #2A, #3A, #4A, and #1B, #2B, #3B, #4B.

How Clear Is The Solution?	
<u>First set of Jars (with lids)</u>	
Jar #1A	_____
Jar #2A	_____
Jar #3A	_____
Jar #4A	_____
<u>Second set of Jars:</u>	
Jar #1B	_____
Jar #2B	_____
Jar #3B	_____
Jar #4B	_____

3. Fill one set of jars (the jars with lids) half full of water.

4. Observe the water in jar #1A. Have students describe it in their chart.

5. Put 1 tablespoon of oil in jar #2A, put on the lid and tighten it. Shake the jar. Have students record their observations.

6. Put 1 tablespoon of vinegar in jar #3A, put on the lid and tighten it. Shake the jar. Have students record their observations.

7. Put 1 tablespoon of detergent in jar #4A, put on the lid and tighten it. Shake the jar. Have students record their observations.

8. Use the second set of jars to continue this activity. Fill the funnel with soil (3/4 full) and place the funnel over the empty jar #1B.

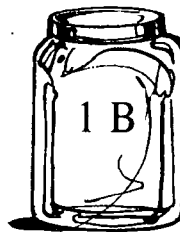
9. Pour the contents of jar #1A (water only) through the funnel into jar #1B. Have students record their observations.

10. Move the funnel with soil to empty jar #2B. Pour the content of jar #2A (oil and water) into funnel. Have students record their observations.

11. Repeat steps with jar #3 (vinegar) and jar #4 (detergent). Have students record their observations. Students may use pH paper to determine if the soil filtered out the vinegar.

12. Have the class discuss their findings and the following questions:

- If these elements were added to a real pond and seeped into groundwater, how would it affect our water?
- How would animals/people be affected?
- Why did we use the same soil in the experiment?



Just Do It

What can you do to protect groundwater?
Never pour any household chemical
on the ground. Remember that chemicals
travel easily from the ground to our
water.

Water Quality

9.DW.2

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

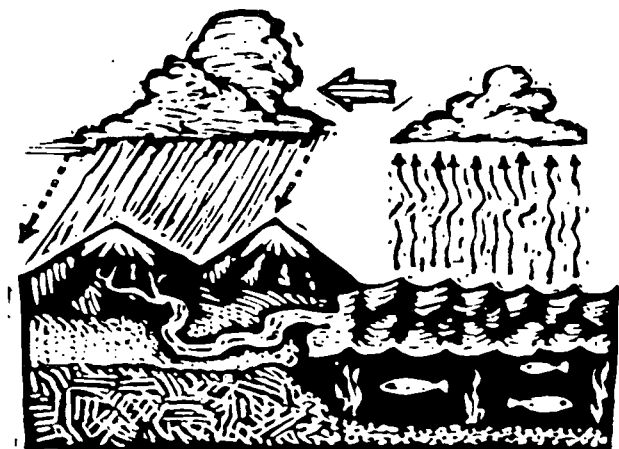
Focus: Water Quality

Subjects: Applied Biology

Materials: thermometer, commercial water test kits to measure the following: chlorine, iron, color, pH, hardness/alkalinity

Teaching Time: one classroom period for prep, then 30 minutes every day for one month

Vocabulary: polar molecule, universal solvent, maximum containment level



Learning Objective

Students will:

- discuss water's ability to dissolve substances
- discuss government regulation of drinking water quality
- test water samples
- compare test results to regulated standards.

Background

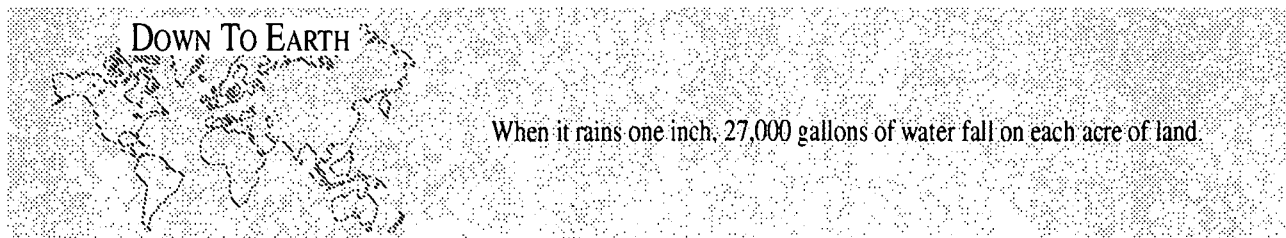
In a water molecule, the two hydrogen atoms and one oxygen atom share the molecule's electrons in a covalent bond. The atoms are positioned so the two hydrogens are together at one end of the water molecule and the oxygen atom is at the other end, forming a "V" shape. While the electrons are shared between all three atoms, the oxygen atom holds the electrons for most of the time and the two hydrogens hold the shared electrons only briefly. This causes a water molecule to act like a tiny magnet with a mild negative charge at the oxygen end of the molecule and a mild positive charge at the hydrogen end. Because the water molecule exhibits definite positive and negative charged ends, it is classified as a **polar molecule**.

Water is also known as the **universal solvent**, that means it has the ability to dissolve most of the substances with which it comes in contact. These substances tend to dissolve because they interact with the weak electrical charges on each end of the water molecules.

As water travels through the hydrologic cycle, it binds to various substances from its surroundings and becomes contaminated. Contaminated water travels down rivers and streams carrying the dissolved materials to the ocean. Some dissolved substances contribute to the oceans' salinity.

If water is to be used for drinking, it must be cleaned of contaminants to make it suitable for consumption. The federal government and the SC Department of Health and Environmental Control have established regulatory limits for more than 80 known contaminants and acceptable levels for other parameters such as pH, temperature, and color.

It is not economical feasible to have totally pure water for drinking. Therefore, there are two standards for allowable levels of drinking water contamination. These are called primary standards and secondary standards. Primary standards directly



affect human health while secondary standards are for more aesthetic qualities such as taste and color. Primary standards can be measured in several ways, one of which is the **maximum containment level**. Maximum containment levels have two categories: maximum containment level goals (MCLG) and maximum containment levels (MCL).

MCLGs are not enforceable and are not associated with adverse health effects from drinking water with this level of contamination.

MCLs, on the other hand, are the enforceable standard and are usually set as close to the MCLG as possible. One factor in establishing MCLs is the cost and technology necessary to attain a specific level of purity. In short, an MCLG would represent a perfect world. The MCL is the contamination level which the public water system may not exceed in order to be in compliance with regulations and still provide safe, healthy drinking water.

A water treatment plant is a busy place. Not only is water being constantly cleaned and disinfected, but it is also constantly monitored for its quality both entering and leaving the plant. Temperature, pH, and chlorine levels are checked around the clock to ensure proper performance of the treatment process. Other parameters are also checked regularly.

Learning Procedure

For this lab, students will be measuring some drinking water parameters at a classroom tap on a regular basis just like a water treatment plant would do. Students will compare their results in this activity with the federal and state standards.

1. Select a source of water to measure. (*This should be readily accessible on a daily basis. A classroom sink is an ideal source for this experiment.*) Divide students into teams.

2. Demonstrate the water test kits and explain the test procedures for measuring each parameter. Have the students determine standard procedures for gathering data so all teams will collect accurate, consistent data. Discuss why this is important.

3. Assign each team a day of the week for collecting and measuring the water from the tap, and recording their data on the enclosed sheet. (*Teachers will need to copy the sheet three times.*)

4. Each day the responsible team should test their water sample for chlorine, color, hardness/alakalinity, iron, pH, and temperature. Follow the procedures given in the test kits and record the data. Continue sampling, testing and recording the data each weekday for one month.

5. Compare the data with the federal and state drinking water levels listed at the bottom of the data recording sheet. Discuss the findings. Were the results what you expected? Did any water samples fail to comply with the standards?

Extension Activities

1. Research what a water treatment plant might do to bring the color, pH, and hardness/alakalinity to the correct levels. What about iron and chlorine levels?

2. In its elemental form, chlorine is a gas. Aeration can be used to liberate excess chlorine from a water sample. Take a sample from the tap and measure the chlorine level using the commercial test kit. Pour this water back and forth between two glasses at least ten times. Remeasure the chlorine level. What has happened to the chlorine reading? Where did the chlorine go? If the chlorine level in your tap water is negligible, put several drops of chlorine bleach in a glass of tap water and use for this activity.

3. Call DHEC's Bureau of Water Pollution Control and ask about water quality standards for treated sewage water (effluent) that is released into the environment. What would have to be done to the treated effluent to bring it to drinking water standards? Find out if any SC rivers serve as both sources for drinking water as well as sites for treated sewage effluent to be released into the environment. (Note: Students might want to locate water treatment plants and sewage treatment plants on a map and discuss why they are placed where they are.)

Date: _____
 Recording Team: _____
 Temperature: _____
 Chlorine: _____
 Color: _____
 Hardness: _____
 Iron: _____
 pH: _____

Date: _____
 Recording Team: _____
 Temperature: _____
 Chlorine: _____
 Color: _____
 Hardness: _____
 Iron: _____
 pH: _____

Date: _____
 Recording Team: _____
 Temperature: _____
 Chlorine: _____
 Color: _____
 Hardness: _____
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Date: _____
 Recording Team: _____
 Temperature: _____
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 Hardness: _____
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 Hardness: _____
 Iron: _____
 pH: _____

Date: _____
 Recording Team: _____
 Temperature: _____
 Chlorine: _____
 Color: _____
 Hardness: _____
 Iron: _____
 pH: _____

South Carolina's Water Quality Standard Parameters

Color, iron, and pH are secondary standards in drinking water. Their ideal levels are:

Color = 15 color units

Iron = 0.3 mg/L

pH = between 6.5 and 8.5

Chlorine = 0.2 mg/L

Hardness/alkalinity and temperature do not have specified levels, but to make the best drinking water, the recommended numbers are:

Hardness/Alkalinity = 15 to 100 mg/L

Temperature = 50 to 60° F



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Transpiration

9.DW.1

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9–12

Focus: Transpiration

Subjects: Biology

Materials: See list below

Teaching Time: Two class periods

Vocabulary: Photosynthesis, transpiration, (Teachers may prefer the term “evapotranspiration”) stomata, guard cells, turgor



Learning Objective

Students will:

- observe various leaf adaptations to conserve water
- observe stomata in both monocot and dicot leaves
- observe the lack of stomata in an aquatic plant leaf
- cause the stomata to open and close in a leaf by changing environmental conditions
- observe open and closed stomata.

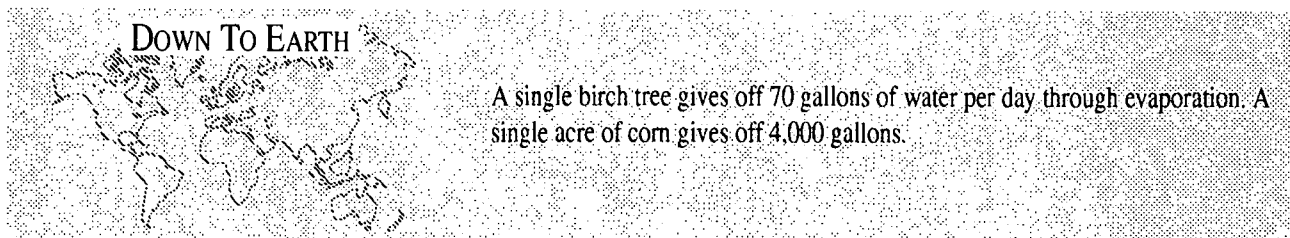
Background

Plants perform the process of **photosynthesis** in order to make their food. During photosynthesis, the chlorophyll in green plants captures light energy which is then converted to chemical energy and stored within the bonds of organic molecules. The energy required to accomplish the process of photosynthesis comes from sunlight. Plants also need water and carbon dioxide as a source for the carbons, hydrogens, and oxygens needed to make organic molecules during photosynthesis. Carbon dioxide is readily available in the air surrounding the plant, but the plant cannot absorb carbon dioxide as a gas. The carbon dioxide enters a plant cell by

diffusion into the water inside the leaf. Any moist leaf surface exposed to air will provide the necessary conditions for diffusion to occur.

Two opposing conditions exist for plants: how to keep their surfaces moist enough so that gaseous carbon dioxide can get into solution, while at the same time not losing too much water to evaporation. It is interesting to observe various leaf adaptations that plants have in order to both gather carbon dioxide and conserve water. Broad flat leaves provide the most surface area to collect carbon dioxide, however, a large surface area allows more water to be lost via evaporation. Plants are in a constant struggle with their environment to gather the materials needed to make food while preventing the loss of too much water.

Most of a plant's water loss occurs through a natural process called **transpiration**. Transpiration is the evaporation of water from a plant's surface. It is unique to land plants. Plants living submerged in water usually do not lose water due to evaporation. During the evaporative process that moves water



9–12
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from the leaf's surface to the air, heat is also lost to the air and the leaf is cooled. Water then moves up the stem from the ground through the roots to replace the water that the leaves have lost. It would almost seem that a "hungry" atmosphere uses the plant like a giant straw to suck up water from the ground.

Not only is water lost from the plant leaves, but heat absorbed from sunlight is also returned to the atmosphere. Some heat is also produced in the plant during cell respiration. Transpiration helps plant life to "maintain its cool" on a hot summer's day. More solar energy is dissipated to the atmosphere via transpiration than is used during photosynthesis to manufacture food.

Many leaves are covered by a thin, waxy covering. This coating prevents both carbon dioxide entry on top of the leaf and water loss at the leaf surface. In order to control water loss and carbon dioxide uptake, terrestrial plants have special structures called **stomata**. Stomata are small openings in the plant's outer layers that can be opened and closed. While stomata are found mostly on the underside of leaves, they can also be found on the top of leaves and on the stems of young plants.

The stomata open into a matrix of air spaces within the leaf. The air inside these spaces in the leaves is saturated with water vapor. By opening and closing the stomata, the leaf can control how much carbon dioxide comes into the plant and how much water is lost via the stomata. Carbon dioxide enters the leaf through an open stomata. Then it comes in contact with the moist air within the leaf, mixes with the water and is diffused into the leaf cells. Opening the stomata allows carbon dioxide in but also lets some water out. Closing the stomata conserves water, but prevents the entry of carbon dioxide. Oxygen produced during photosynthesis must also exit the stomata, making its opening and closing part of a complex process.

Stomata are surrounded by two special cells called **guard cells**. The guard cells allow the stomata to open and close. They do so in response to something called **turgor**. Turgor is a fullness or

tension caused by fluid content. Changes within the guard cell cause changes in turgor which then affect the stomata. When the guard cells are swollen and full of fluid, the stomata are forced open. The guard cell walls are a bit thicker next to the stomata. When the guard cells become swollen, the thinner parts of the cell wall stretch causing the stomata to bend in and open. When the guard cells are shrunk, the stomata flatten and close. Many different environmental conditions cause the stomata to open and close. In this activity students will observe stomata in various kinds of leaves and under various conditions to observe both open and closed stomata.

Transpiration is an important process on the planet Earth. It plays a large role in the water cycle by returning water from the soil to the atmosphere. It also plays a large role in dissipating heat gained from solar energy.

Materials

- an assortment of labeled leaves (magnolia, coleus, grass, corn, bean, etc.)
- several potted houseplants with hard waxy leaves. (You will need to test several to find which works best for you.)
- fresh leaves from a green onion
- fresh leaves from an *Elodea* plant
- single edged razor blade or sharp paring knife
- microscope slides and cover slips
- microscope
- paper saucer, aluminum pan, or petri dish
- dropper bottles with filtered pond water
- sugar and water solution
- large paper bags
- observations sheets (included)

Learning Procedure

Divide students into teams and assign each team a microscope. The students should already have basic microscopy skills.

Day One, Part One

1. Have each team pick out five different leaves from a selection of labeled leaves.

2. Examine each leaf and complete the observations 9-12 sheet.

Day One, Part Two

1. Pick a leaf from the houseplant and peel off a thin layer from the underside. Place on a microscope slide and prepare a wet mount with filtered pond water. Observe under the microscope, first at low power and then at a higher power. Look for the stomata. Note whether they are open or closed at this time. Repeat using the top layer of the houseplant leaf. Are there any stomata on the top of the leaf? Estimate the number of stomata on the underside of the whole leaf.

2. Pick a green leaf from an onion and peel off a thin layer. Repeat #1.

3. Pick a leaf from the *Elodea*. Repeat #1.

4. List any differences you have observed between the houseplant and onion leaf stomata. List any similarities. Did the *Elodea* have any stomata?

Day One, Part Three

Cover the houseplants with paper bags and store them in a dark place.

Day Two, Part One

1. From the covered houseplants that have been stored in a dark place, remove a fresh leaf. Peel off a thin layer of the underside and make a wet mount with filtered pond water.

2. Observe and record whether the stomata are open or closed.

3. Then expose the whole plant to light by removing the paper bag and placing the plant under a strong light or close to a sunny window. Wait 30 minutes.

4. After 30 minutes, make a wet mount of the underside of a leaf in filtered pond water. Observe: Are there any differences between the stomata from the leaf in the dark and the leaf in the strong light? Are all of the stomata from the underside of the leaf in the same position (open or closed) at once?

Day Two, Part Two

1. Pick a fresh houseplant leaf. Put into a paper saucer, disposable pan or petri dish. Add enough sugar solution to cover the leaf. Wait 15 minutes.

2. Peel off a thin underside layer of the leaf and place it on a glass slide using a drop of the sugar and filtered pond water solution.

3. Make a second houseplant leaf slide with water but use a leaf that was NOT soaked in the sugar solution. Observe the stomata and record any differences. If the students do observe differences in the stomata, discuss what might be causing them.

Day Two, Part Three

1. Design an experiment to compare differences in stomata behavior in plants that are chilled and plants exposed to dry, hot temperatures (above 95° F).

2. As a class, discuss the following:

a. the factors that may or may not control stomata:

- temperature
- light/dark
- relative humidity
- wind
- previous moisture history
 - plant at or near its wilting point?
 - soil moisture

b. the function of the stomata.

c. how the exchange of water through plants affects the water cycle.

d. what would happen to the atmosphere is plants were not longer capable of giving up water to the atmosphere.

e. what would happen to our atmosphere if the number of plants on Earth diminished significantly.

Extension Activity

Have students paint a thin layer of clear fingernail polish on the underside of a leaf. Let it dry overnight. The following day, peel and mount in a microscope slide. Observe the stomata.

Name: _____

Date: _____

OBSERVATIONS**Leaf #1**

Type of leaf: _____

- a. Is the leaf large, medium or small? _____
- b. Is the leaf thin or thick? _____
- c. Does the leaf have a thick outer covering or is it soft and pliable? _____
- d. Can you easily tear the leaf? _____
- e. Do you think this leaf would retain water well or lose water easily? _____

Why? _____

Leaf #2

Type of leaf: _____

- a. Is the leaf large, medium or small? _____
- b. Is the leaf thin or thick? _____
- c. Does the leaf have a thick outer covering or is it soft and pliable? _____
- d. Can you easily tear the leaf? _____
- e. Do you think this leaf would retain water well or lose water easily? _____

Why? _____

Leaf #3

Type of leaf: _____

- a. Is the leaf large, medium or small? _____
- b. Is the leaf thin or thick? _____
- c. Does the leaf have a thick outer covering or is it soft and pliable? _____
- d. Can you easily tear the leaf? _____
- e. Do you think this leaf would retain water well or lose water easily? _____

Why? _____

Leaf #4

Type of leaf: _____

- a. Is the leaf large, medium or small? _____
- b. Is the leaf thin or thick? _____
- c. Does the leaf have a thick outer covering or is it soft and pliable? _____
- d. Can you easily tear the leaf? _____
- e. Do you think this leaf would retain water well or loose water easily? _____

Why? _____

Leaf #5

Type of leaf: _____

- a. Is the leaf large, medium or small? _____
- c. Is the leaf thin or thick? _____
- b. Does the leaf have a thick outer covering or is it soft and pliable? _____
- d. Can you easily tear the leaf? _____
- e. Do you think this leaf would retain water well or loose water easily? _____

Why? _____

ASSUMPTIONS

Using the observations and your intuition, rank your leaves, by name, in the order from which leaf would lose the most water to which leaf would best retain water.

Looses water easily

- 1. _____
- 2. _____
- 3. _____
- 4. _____
- 5. _____

Retains water



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Sun Bathing

9.3R.5

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

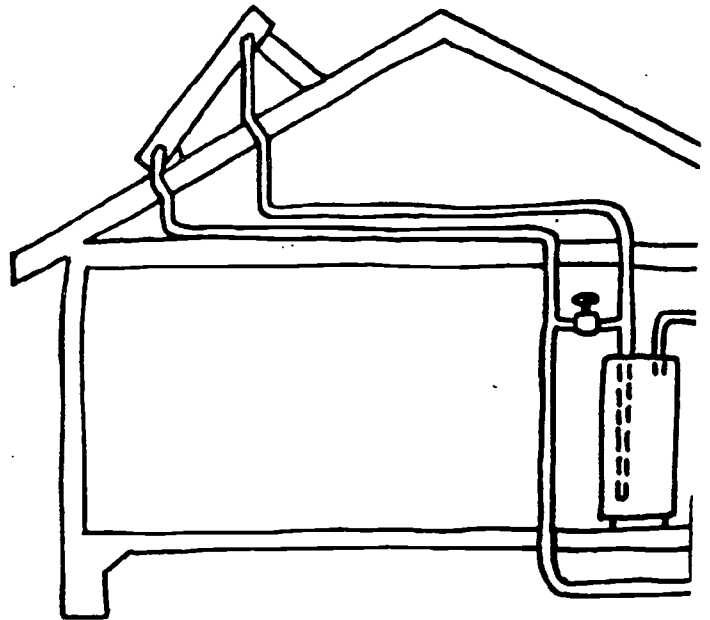
Focus: How solar water heaters work.

Subject: Science, Environmental Science

Materials: See itemized list

Teaching Time: Two class periods

Vocabulary: solar collector, passive solar, active solar



Learning Objective

Students will:

- create a model solar water heater.

Background

Using the sun to heat water for household purposes (laundry, bathing, cleaning) is not a new idea. In California and Florida, simple solar water heaters were manufactured and sold as early as 80 years ago. The theory is simple. Cold water is pumped from a supply source – a well or municipal system – to a south-facing solar collector. This collector is a panel, often mounted on the roof, that is designed to collect solar energy and transfer that energy to heat the water. The water travels through a network of pipes in the collector and, as the sun shines, the water heats up. The hot water then circulates to an insulated storage tank, much like a traditional water heater, where it is kept warm until used.

Water temperature in the collector can reach 180°F, most household uses require only about 120° or less.

Materials

To make a model solar water heater, you'll need:

- cardboard or wooden box (approximately 36" x 48" about 8" deep)
- rigid foil-faced insulation board (enough to line box)
- flat black spray paint
- aluminum-backed tape
- utility knife
- garden hose
- 6 to 8mil polyethylene
- thermometer
- bucket or gallon plastic jug
- watch or clock that measures seconds
- cellophane tape
- permanent marker
- work space outside
- site outside with a faucet and full sun at the time you'll be conducting the experiment.

DOWN TO EARTH

An affordable housing development in Dallas, Texas, has slashed utility bills by \$450 a year per dwelling by incorporating solar heating and efficient appliances that add only \$13 a year to mortgage payments.

source: *WorldWatch Institute*

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There is increasing acceptance of solar energy. After all, solar energy is readily available throughout the country, the technology for putting the sun to work is developed, and the sun's energy is free. The sun's energy is clean and nonpolluting.

The two basic types of solar energy systems in use are **passive and active solar systems**.

Passive solar systems are relatively inexpensive, have no maintenance requirements, and last indefinitely because there are no moving parts to wear out. They do not provide for long-term heat storage nor for automatic control of the heat.

Active solar systems are more expensive because they require the installation of special equipment. Active systems do provide for heat storage and they do have automatic controls.

Passive Solar Systems

In a passive solar heating system, the structure is designed to capture heat during daytime hours and to gradually release that heat during night time hours. It has no means to transfer the heat energy from one room to another except by natural heat flow.

Building made from stone, brick, concrete walls and ceilings or floors soak up heat and release it when the outside temperature drops. Window shutters and extra insulation slow down the heat transmission from the building. These systems provide large amounts of free energy.

Active Solar Systems

An active solar system consists of equipment to trap the sun's heat and to use the heat for hot water and/or space heating. These systems usually have automatic controls.

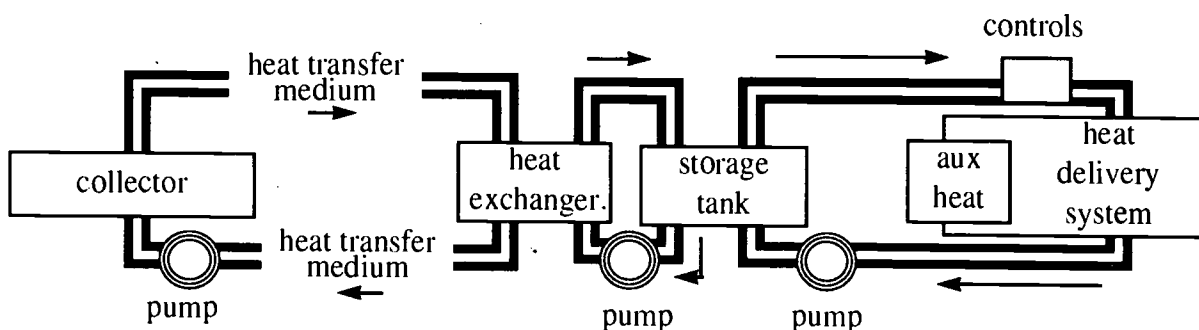
The illustration below shows the components of an active system.

The collector is the means by which the system traps the sun's energy. It is normally mounted on the roof. In its simplest form, the solar collector is nothing more than a flat box with a clear piece of clear plastic or glass over its surface. The sun's energy flows through the cover and is trapped inside.

The collector usually has tubes inside which contain a heat transfer medium, this may be water. This liquid is heated and circulated through the system by pumps. The heated liquid is pumped to a storage tank, usually a tank of water. When heat is needed, pumps circulate the hot liquid to a heat exchanger, a device that looks like a car radiator. Warm water is pumped through the coils and air from the building is blown across the fins on the coils and warmed for heating.

This is a forced heat-delivery system. These systems also have controls that work much the same as thermostat controls.

Because the sun doesn't shine 100 percent of the time, the system has auxiliary heat from a conventional source.



The major components of a simple solar energy system for hot water and space heating.

Learning Procedure

Making a model flat plate solar collector can be done as a class project or several groups can assemble a collector and test it. It is best to allow one class period to assemble the materials and make the collector and another class period to perform the experiment.

Day One: Making the Model

1. To assemble the model solar water heater, insulate the inside of your box (no top on the box) with the insulation board. You will need to pre-cut the board to fit the bottom and sides of the box. Please pre-cut this for students. Place the insulation on the bottom first, then sides and tape in place with the aluminum tape. This is done to help retain the heat.

2. On the side panels of the box, cut small holes large enough to poke the garden hose through (see

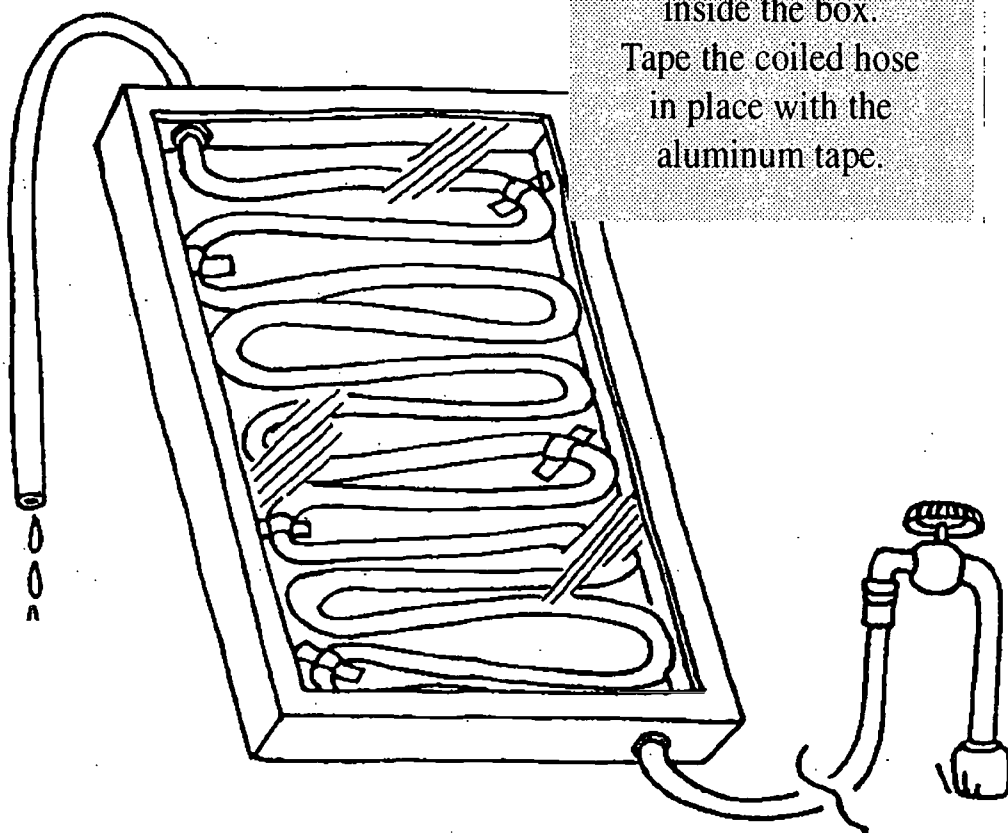
illustration) the holes should be cut in the short sides of the box to allow the hose to travel the through the box.

3. Spray paint the inside of the box flat black and allow to dry.

4. While the box is drying, cut a piece of polyethylene large enough to cover the top of the box plus a selva of about two inches around. This plastic will be used later as the glazing or clear window cover for the collector. Do not install it yet.

5. Put the end of the garden hose through one of the side holes and pull through the box and out the other hole. Leave about 12 inches of the sticking out of one end of the box. Secure this end of the hose to the outside of the box at the opening, sealing the opening at the same time. (See illustration.)

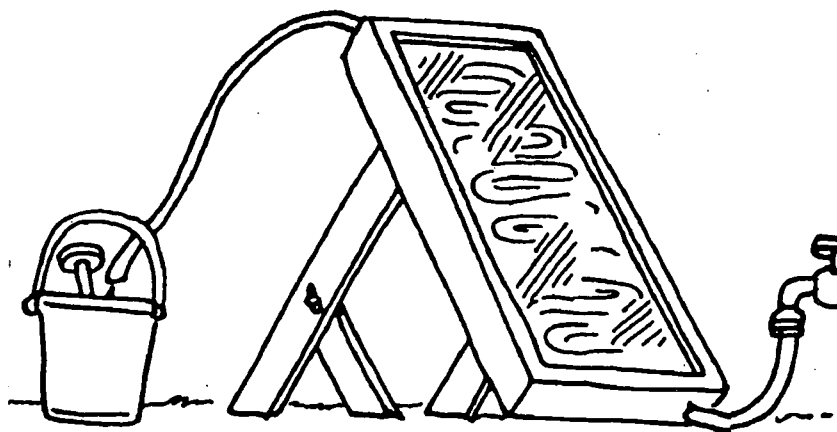
6. Tightly coil the hose inside the box. Tape the coiled hose in place with the aluminum tape and secure the other end of the hose to the box, sealing the hole. Be sure to leave enough hose extending from the box to reach the faucet and to allow your model collector to be placed in full sunlight.



Day Two: Testing the Model

7. **Ask the class:** Before we hook up the collectors to the faucet, will the rate of flow affect how hot the water gets? *Why? (Yes, the rate of flow will determine how long the water is exposed to the heat. As the water flows through the pipes, it warms up with energy from the sun. The longer it stays in the pipes, the more heat it can absorb.)*

For this reason, it is important to set the rate of flow of the water. To do this, use a one gallon jug or bucket, and with a permanent marker, mark lines on the side for each quart level.



Hook your collector to the faucet. Place the marked bucket or jug to collect the water at the end of the collector. Turn the faucet on at a low volume and measure the amount of water as it comes out of the collector. Time the flow in seconds and adjust the faucet so that **the rate of flow equals one quart every three minutes.**

8. To test the collector: First, test the collector without the plastic glazing. Set the collector in full sun at an angle as close to perpendicular to the sun's rays as possible.

Measure the temperature of the water as it leaves the faucet and record.

9. Connect the hose to the collector, turn on the water, adjust the rate of flow to one quart every three

minutes, and let it run during the experiment.

10. Measure the temperature of the water as it leaves the collector every minute for 15 minutes and record.

11. Ask the class: What effect will adding a cover or glazing have on the temperature of the water? *Why? (The temperature will increase because the glazing will hold the heat inside the box.)*

Now test the collector with the glazing. Tape the plastic cover over the box and test as before. What effect did the glazing have and why?

Extension Activity

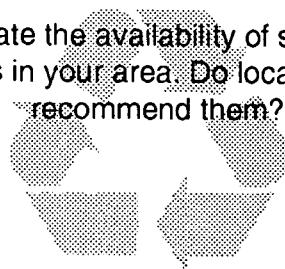
1. Try some variations to your flat plate solar water heater model.

Double the rate of flow and repeat the test. What affect does this have and why?

2. Try lining the inside of your box with different colors – mask the flat black paint with colored poster paper. How does color affect the absorption of heat?

Just Do It

Investigate the availability of solar water heaters in your area. Do local builders recommend them?



Model Solar Collector

Results Record

Time	Temperature (without glazing)	Temperature (with glazing)
1 Minute	Temperature:	Temperature:
2 Minutes	Temperature:	Temperature:
3 Minutes	Temperature:	Temperature:
4 Minutes	Temperature:	Temperature:
5 Minutes	Temperature:	Temperature:
6 Minutes	Temperature:	Temperature:
7 Minutes	Temperature:	Temperature:
8 Minutes	Temperature:	Temperature:
9 Minutes	Temperature:	Temperature:
10 Minutes	Temperature:	Temperature:
11 Minutes	Temperature:	Temperature:
12 Minutes	Temperature:	Temperature:
13 Minutes	Temperature:	Temperature:
14 Minutes	Temperature:	Temperature:
15 Minutes	Temperature:	Temperature:



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Nuclear Power in Our State

Preparation Time:

Easy-To-Do

Moderate

Extensive

Grade: 9 – 12

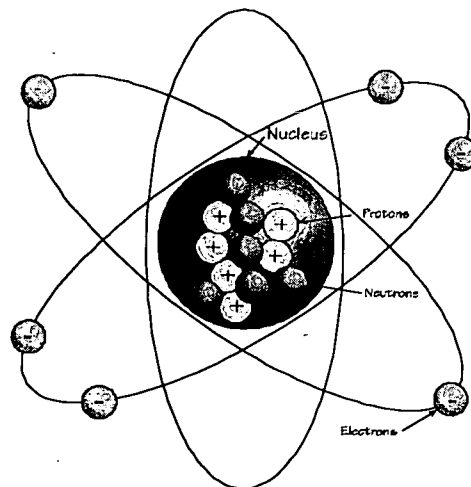
Focus: The story of nuclear power in South Carolina.

Subject: History, Social Studies, Science

Materials: Handouts included with this lesson.

Teaching Time: Several class periods, including student research and writing time

Vocabulary: nuclear reactor, nuclear waste



Learning Objectives

In this lesson, students will

- explore the history of nuclear power in South Carolina
- see how much of our electricity comes from nuclear power
- examine why some people are concerned about nuclear power.

Materials

This lesson includes a "Timeline of nuclear power in South Carolina" handout for students to read. The timeline was compiled from articles that ran in *The State* newspaper and is supported by excerpts from the chapter on nuclear energy from the *Energy FactBook: A Resource for South Carolina* produced by the South Carolina Energy Office.

Did You Know...

- Nearly two-thirds (62%) of South Carolina's electricity is generated by nuclear power.
- Of the 50 states, only Illinois and Pennsylvania consume more nuclear energy than South Carolina.
- Barnwell County is one of three sites in the U.S. where low-level¹ nuclear wastes are stored.
- One gram of waste results from one megawatt-day of nuclear reactor heat energy production. In contrast there is a weight of some 2.5 tons of waste solids and gases from burning fossil fuels such as coal to produce the same amount of heat. That's right. One gram of waste from nuclear power production compares to 2.5 tons of waste and gases from burning fossil fuels. However, this comparison does not factor the dangers of the waste. Nuclear waste, while small in volume, is highly toxic. source:

Understanding Radioactive Waste by Raymond L. Murray

¹Low-level wastes include gloves, clothing, and tools that have been contaminated by radiation.



Japan is a major user of nuclear power, producing 202,271 gigawatt-hours of electricity per year.

source: 1994 *Environmental Almanac*

Timeline

of Nuclear Power in South Carolina

1950 - Almost eight years after the first controlled nuclear chain reaction took place in 1942 under the direction of Enrico Fermi, it was announced that South Carolina would be the sight for a \$260 million nuclear weapons plant. The Savannah River Site would occupy 300 square miles (192,000 acres) of rural farmland and was heralded as a boom for the state's economy.

Nuclear energy represented the largest industry South Carolina had ever known. The plant would produce plutonium and tritium to be used in the country's national defense program. *The State* newspaper reported on its front page that the plant selection moved South Carolina to the "forefront in the battle against the Communist menace." The facility is one of 14 weapons research, production, testing, and assembly facilities in 12 states. This site is not a power generating facility.

1954 - Congress passed the Atomic Energy Act and President Dwight D. Eisenhower began the Atoms for Peace Program to promote the commercial use of nuclear materials for peaceful purposes.

1957 - Carolina Power & Light (CP&L), Duke Power and South Carolina Electric & Gas (SCE&G) joined with Virginia Electric and Power Co. to form the Carolinas-Virginia Nuclear Power Associates. This group agreed to build the Parr nuclear power facility, a small, 17 megawatt reactor to produce electricity. This was designed as a research and development project.

1963 - The Parr nuclear power plant, the first nuclear power plant in the Southeast, began operation. It was located 25 miles northwest of Columbia at Parr, South Carolina.

1966 - Carolina Power & Light begin construction on a 665 megawatt nuclear plant in Hartsville, the Robinson reactor.

1966 - Duke Power began plans to build two reactors that would comprise the Oconee nuclear plant. Plans for a third reactor were added the next year.

1967 - The Parr nuclear reactor experiment was shut down and sealed shut. The tiny reactor was determined not to be economical to operate. Each of the power companies involved in the project went on to pursue nuclear power.

1967 - The Federal Atomic Energy Commission (AEC) began looking for a site to handle spent nuclear fuel reprocessing. In May the South Carolina legislature passed legislation to allow spent nuclear fuel reprocessing in the state.

The AEC selected Allied Chemical to build the site in Barnwell, South Carolina. At the time, spent fuel reprocessing was an important component in nuclear power. The process allowed nuclear fuel rods to be recycled and used again.

1969 - Duke Power began planning a two reactor nuclear power plant, the Catawba Plant in York County. These were scheduled for completion in 1983 and 1985.

1970 - A Harris Poll conducted in South Carolina found that 52 percent of residents favored nuclear energy. Most of the people polled ranked the state's atomic industries at/or near the top in working conditions, pay scales, high-caliber employees, and community leadership.

1971 - Carolina Power & Light's Robinson reactor near Hartsville began operation.

1971 - Construction began on an \$80 million facility – Barnwell Nuclear Fuels Plant – to reprocess nuclear fuels.

1973 - Chem-Nuclear Systems opened as a low-level nuclear waste burial site in rural Barnwell County.

1973 - The oil-embargo and fossil fuel crisis hit. This focused attention on America's dependence on foreign sources for energy and our dependence on fossil fuels.

1973 - The first Duke Power Oconee nuclear reactor came on line in July 1973. and September and December 1974.

1973 - Duke Power begins plans for a three reactor nuclear power facility in Cherokee County.

1973 - South Carolina Electric & Gas begins plans for a 900 megawatt nuclear reactor near Jenkinsville in Fairfield County. The company said that its customer load could not justify a large facility, even though larger plants were cheaper per kilowatt hour to construct. The Public Service Authority (Santee Cooper) agreed to purchase one-third of the plant's generating capacity.

1973/1974 - Duke Power's Oconee Units 2 and 3 begin generating electricity.

1977 - President Jimmy Carter announces a moratorium on commercial spent fuel reprocessing. This meant that the Barnwell reprocessing facility could not be opened as planned. Spent fuel reprocessing produces small amounts of nuclear fuel that in the hands of terrorists could be used to build nuclear weapons. Carter considered commercial spent fuel reprocessing dangerous to national security.

Utilities had planned from the beginning of nuclear power operation to one day send their accumulating spent reactor fuel rods to privately operated reprocessing centers for recycling. In South Carolina, the Barnwell Reprocessing plant was nearing completion. The investment in the Barnwell plant was estimated to be \$360 million. Used fuel was to be recycled to capture uranium and plutonium that could be reused in a plant's reactor.

Utilities had never considered spent fuel as a waste product. They thought of it as a valuable, reusable commodity. With the moratorium, nuclear plants for the first time became producers of a dangerous waste product.

President Carter declared the ban because of a growing concern about the environmental dangers of reprocessing and to guard against terrorist theft of deadly plutonium gleaned from reprocessing. Spent fuel

that had been building up at reactor sites since plants started operation, had to be stored indefinitely. Controversy about what to do with the facility began.

1979 - Nuclear power generated 46 percent of the state's electricity.

1979 - A reactor at the Three Mile Island plant in Pennsylvania malfunctioned.

New safety requirements issued by the Nuclear Regulatory Commission were estimated to double the cost of building a nuclear plant.

1981 - The S.C. Department of Health and Environmental Control, at Governor Dick Riley's insistence, cut in half the amount of low-level nuclear waste allowed in at the Chem-Nuclear Barnwell nuclear waste burial site.

1984 - South Carolina Electric & Gas begins operation of the V.C. Summer nuclear plant near Jenkinsville.

1985 - Duke Power's Catawba nuclear plant began generating electricity.

1992 - The Nuclear Regulatory Commission declared the V.C. Summer nuclear plant in Jenkinsville one of the four safest in the nation.

1995 - More than 60 percent of South Carolina's electricity is generated by nuclear power. There is still controversy about our state's nuclear involvement. The state's four nuclear power facilities, the Barnwell low-level nuclear waste burial site, the Savannah River Site, spent nuclear fuel, and the transport of nuclear materials through our state are still issues that create debate.

Sixteen years after the Three Mile Island nuclear accident, not a single nuclear plant construction permit is pending before the Nuclear Regulatory Commission. No one has proposed building a nuclear plant in the United States since 1978. Across the country, 109 nuclear power plants generate 20 percent of the nation's electricity.

Learning Procedure

1. Introduce the topic of nuclear power using the pages from the *Energy FactBook* and the *Timeline* and have the class participate in a discussion.

Questions for discussion include:

- What are the pros and cons of nuclear power? (*Pros include reduced pollution from conventional power generation that burns fossil fuels, less dependence on nonrenewable fossil fuels, economic power source. Cons include nuclear waste disposal and safety concerns.*)

- What is the difference between a nuclear power plant and the Savannah River Site? (*A nuclear power plant is owned and operated privately. These facilities use nuclear fission to create the heat source that is used to create the steam that turns the turbine that generates electricity. The Savannah River Site is a federal government facility that produces materials to be used in producing nuclear weapons.*)

- If South Carolina did not have nuclear power generating facilities, how would we generate the electricity we need? (*There is no single answer to this. Have students speculate on other methods, more coal-fired power plants, more hydroelectric plants, alternative energy sources such as solar, etc.*)

2. Start a nuclear power bulletin board in the classroom. Have students search out books, articles, and newspaper clips about nuclear power worldwide and in South Carolina. Be sure to have students distinguish between issues that face the generation of electricity using nuclear power and nuclear weapons production. Discuss how the public might confuse these issues.

Good sources for information on nuclear energy include:

- *Understanding Radioactive Waste* by Raymond L. Murray, Battelle Press, 1989.

- *The State* newspaper (The Record edition), "The Nuclear State" Saturday April 12, 1980.

- *The 1993 Information Please Environmental Almanac* compiled by the World Resources Institute, "Cleaning up after the Cold War" p. 129.

- *Energy for Tomorrow's World* by the World Energy Council, St. Martin's Press, 1993.

3. Ask students to figure out how old they will be in the year 2020.

Ask them to describe their lifestyles in the year 2020. (*Many will estimate that they will be working, have a family, own a home, nice cars, etc.*)

Ask students to describe what their energy needs would include. (*Most will include heating and air conditioning for a large home, several TV's, computers, other electronics, etc.*)

Explain to students that experts estimate that by the year 2020 the world's energy demands will double.

Ask: Where will all this energy come from? (*Remind students that many fossil fuels, particularly oil and natural gas may be in shorter supply and more expensive, also remind them that currently South Carolina depends on nuclear power for much of its electricity.*)

Have students write an essay describing their lifestyle in the year 2020 in terms of the energy they will use. Have them include how the energy will be generated, will South Carolina continue to produce nuclear power? If so, where will new plants be located? What will happen to the nuclear waste? Where will nuclear waste facilities be located? If not, what will replace nuclear power?

Nuclear Energy

excerpts from the *Energy FactBook, a Resource for South Carolina*

Nuclear energy plays a major role in South Carolina's energy picture and holds great promise for our energy future. It offers an alternative to fossil fuels. At the same time, it carries with it the need for responsible use.

WHAT IS NUCLEAR ENERGY?

Nuclear energy is energy released by a nuclear reaction. The process of releasing energy from atoms is difficult to achieve. To understand it, you need to know that matter — which is everything that occupies space — is made up of atoms. In the center of every atom is a nucleus. Inside the nucleus are particles known as neutrons and protons. Traveling around the nucleus are electrons.

In the diagram of a carbon atom shown here, there are an equal number (6) of protons and neutrons in the nucleus. Six electrons circle the carbon nucleus.

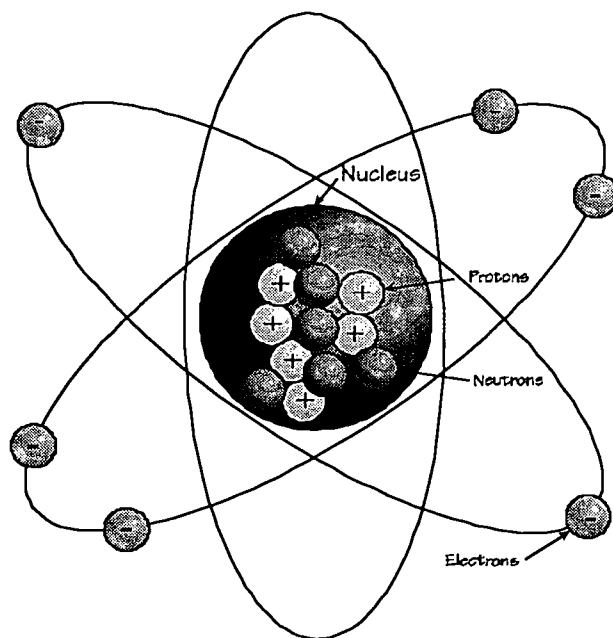
When some atoms are bombarded by neutrons they can be made to split, releasing great quantities of heat energy. The process of splitting atoms to release energy is known as **fission**.

When an atom splits, neutrons from its nucleus are shot out at high speeds. They, in turn, cause other atoms to split. A chain reaction is thus set in motion.

The first controlled nuclear chain reaction took place at the University of Chicago on December 2, 1942 under the direction of Enrico Fermi. This event ushered in the **Atomic Age**.

HOW NUCLEAR ENERGY IS PRODUCED

The vast power of nuclear energy can be made to work for us. For example, all nuclear plants convert the nuclear energy in uranium to electrical energy we can use. When the heat energy produced by fission is transferred to water, it creates steam. The steam powers a generator to make electricity.



HOW A NUCLEAR PLANT WORKS

In a nuclear power plant, fission occurs in the nuclear reactor. The heat energy produced by fission is captured to use in making steam to run the plant's generators.

Uranium is the fuel used in nuclear power plants. Uranium pellets are stacked in long, metal fuel rods, which are bundled together to form fuel assemblies.

To regulate the fission process, control rods (steel rods containing boron) are used. They act as "neutron sponges." By raising or lowering the control rods into the reactor, the chain reaction is increased or decreased. For example, when the control rods are lowered, the number of neutrons available for fission is reduced. This slows down or stops the chain reaction.

The heat produced in the nuclear reactor is transferred to water which cools the reactor. The water does not boil because it is under pressure. Water flows through the primary system indirectly heating water in the steam generator to produce steam. The steam spins turbines that generate electricity. Water in a closed system condenses the steam. The steam is then returned to the generator to be reused.

9-12
PAGE
315

USING NUCLEAR ENERGY RESPONSIBLY

In a world with limited fossil fuels, many people feel nuclear energy has great prospects. It is considered to be "clean energy." Nuclear energy does not pollute the atmosphere because the fuel is not burned.

Two main concerns do, however, persist with nuclear energy — radiation and waste disposal. Every time fission occurs, invisible particles are released. These particles, or radiation, can be harmful. To prevent radiation from escaping the reactor in which it is isolated, many safeguards have been put into place.

U.S. nuclear power plants are tightly regulated to make sure that radiation leakage does not occur. No nuclear facility can be built or operated without a license from the U.S. Nuclear Regulatory Commission (NRC). Plants are carefully monitored by NRC inspectors, as well as employees.

Likewise, proper disposal of nuclear waste is essential in the safe use of nuclear fuel as energy. This is especially important to us in South Carolina since Barnwell County is one of three sites in the U.S. where low-level nuclear wastes are stored. Some of the precautions taken in handling nuclear wastes include:

- Burying the waste containers in water-proof trenches
- Regularly checking nearby water wells to ensure that no radiation has escaped, and
- Closely monitoring the area to make sure that the waste containers remain undisturbed.

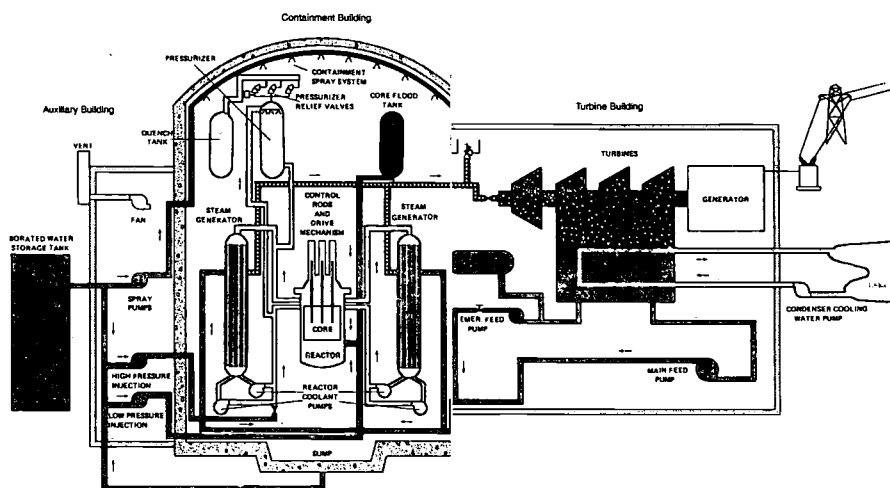
NUCLEAR ENERGY IN SOUTH CAROLINA

Since the early 1970's, South Carolina has been a leader among states with regard to the use of nuclear power. Of the 50 states, only Illinois and Pennsylvania consume more nuclear energy than South Carolina.

In South Carolina we have been able to reduce our use of fossil fuels because of our extensive use of nuclear energy. Over one-third of the state's energy needs are currently being met by nuclear energy. Nearly two-thirds (62%) of the electricity we produce comes from nuclear power.

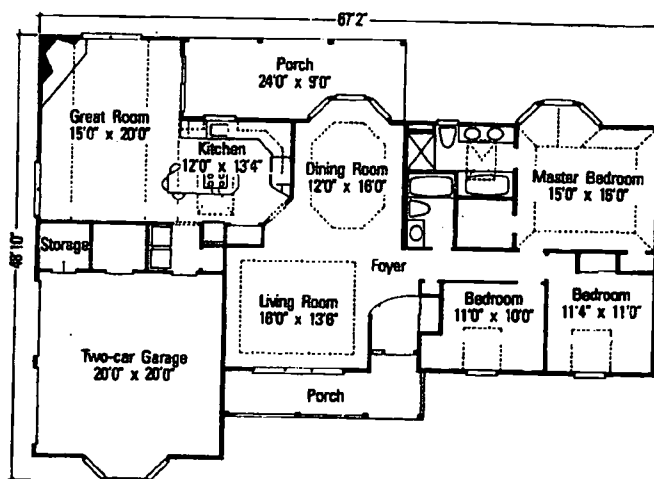
With the opening of the Oconee plant in 1973, South Carolina became the first state in the South to use nuclear energy for electrical generation. Today there are four nuclear plants operating in the state. These include the Oconee plant, H.B. Robinson in Darlington County, V.C. Summer in Fairfield County, and the Catawba plant.

South Carolina's nuclear facilities have proven to be cost-effective investments. The Oconee plant paid for itself in just 8 years. In its first 10 years, it became the nation's leading producer of nuclear-generated electricity.



Extensive

Vocabulary: passive solar heating, fixed overhangs



- examine how controlling solar radiation can improve energy efficiency
- discuss home design for energy efficiency
- create their own home design for energy conservation.

1. Place the cardboard box on a table so that students can see it. The box will simulate a house. Using a marker, draw in windows and doors. Use the flash light to simulate the sun rising in the east, tracking across the wall and roof of your box house, and setting in the west. (*See the sun's path in the illustration on the student information sheet.*) **Ask:** What difference does the orientation of a house – facing east, west, north, or south – make in siting a home? (*It will determine how the sunlight/heat streams into the house.*) **Ask:** Can you think of any reasons why you might want to consider which way

the house faces? (*You may want to avoid intense sunlight in summer and/or use sunlight to help heat your home in winter.*) Which direction does your bedroom window face? Do you prefer warm sunlight streaming in in the morning, or would you prefer to have the afternoon sun warm your room? How about light and heat coming in to the kitchen?

2. Hand out the student project information and work sheets and explain to students that they are going to select a lot in a neighborhood, site a house on the lot, and make decisions on landscaping and building designs for energy efficiency.

3. Give students at least a week to read the energy efficient design information and complete the worksheets. Then have students present their ideas to the class. For more advanced classes, have students create a model of their home highlighting energy-efficient designs or prepare simple site blueprints showing the placement of the home on the lot, landscaping, and other features.



source: 1994 Environmental Almanac

DESIGN CONSIDERATIONS FOR ENERGY EFFICIENCY

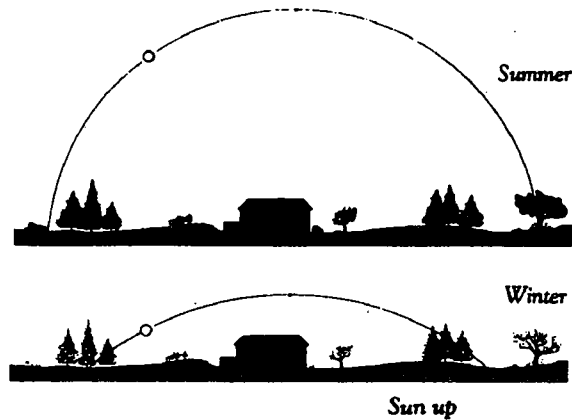
Siting the House

Home orientation – facing north, south, east, or west – is important to know when planning the layout of rooms, windows, porches and overhangs and even landscaping to maximize energy efficiency. A house with a large bank of unshaded windows facing due west will be expensive to keep cool in the summer. It is important that selection of the lot be made in conjunction with the design of the house and your preferences for comfort. For example, do you want morning sun streaming into bedroom windows, or do you prefer afternoon sun coming into bedrooms while you are out? Do you want to have a sunny kitchen for breakfast? Will intense afternoon sun be a problem for the windows in a family room?

As the sun rises in the east, travels across the sky, and sets in the west, the south side of a home receives solar radiation most of the day; the east side only in the morning; and the west side only in the afternoon. The north side does not receive any radiation.

The north-facing exterior wall is always the coldest wall. To reduce heat losses in winter, the north-facing exterior wall should have high resistance to heat transmission. It should be protected from winds, perhaps by evergreens. A dark color will help absorb the maximum amount of reflected solar radiation. In the summer, the north-facing wall should have some means for drawing in cool air.

The east- and west-facing exterior walls should have more windows than north-facing walls and have provisions for letting light in or shading. Solar radiation is only available during limited hours of the day, so awnings, blinds, shutters and other light controlling devices are good ideas. Deciduous plants – that drop leaves in the fall – can provide summer shade and let in winter sun.



The south-facing exterior wall is critical. This is the wall that receives the most heat energy from the sun's rays. It is always the hottest wall of the structure. The possible treatment of this wall is dependent on its function and geography – in colder climates its solar radiation can be used for heating and in warm climates it must reflect solar energy to save on cooling costs.

Large window walls can collect solar heat in winter. In summer when shade is needed, awning, overhangs, and other controllable devices such as shutter and blinds help. Deciduous trees can provide summer shade as well. Control of south-facing solar radiation can reduce energy costs considerably. A 40-foot-long, 8-foot-high south wall can receive more than 200,000 Btu on a sunny day (five hours of direct sun). For a 120-day heating season with only 50 percent sunshine, that is more than 14 million Btu. These savings are lost though if the solar radiation isn't controlled in the summer when air conditioners are running.

Landscaping

Landscaping can increase energy efficiency by shading hot summer sun and protecting the house from wind. Planting deciduous trees that provide summer shade and then lose their leaves in winter to let warm sun shine in can be beneficial.

Evergreens can be used to shield a house from cold winds.

Fixed Overhangs

A fixed horizontal overhang on the south side of a house is a widely used feature associated with passive solar heating systems. An overhang on the south side of a house is used to regulate solar (sunlight and heat) gains on a seasonal basis. Fixed overhangs work by blocking high-angle summer sun while allowing low-angle winter sunlight to reach south facing windows.

The concerns in designing a fixed overhang are the length and width of the overhang and the size of the separation between the bottom of the overhang and the top of the window. The length of the overhang is the primary factor that determines the period of time that the overhang will shade the window.

The most effective overhang length will vary among locations, depending on the relationship of the particular site to the sun. For example, a two foot overhang might shade a window throughout the summer on a house located at 32° latitude but leave the window partially unshaded on the same house at 40° latitude. This is because the summer sun is at a lower altitude angle in northern latitudes, so a longer overhang will be needed to block the direct sunlight (See Figure 1).

The width of the overhang is another design consideration. The overhang should extend beyond the window on either side to block the lower morning and afternoon sun. The extension of the overhang depends on the window configuration. If the window is narrow and long, the overhang should extend a substantial distance beyond the window on either side to provide full shade. On the other hand, if the window is wide and short, the overhang need only extend slightly beyond the width of the window to shade it.

The heating and cooling needs of the individual residence should be considered in sizing an overhang. An overhang that is sized to provide full shade throughout the entire cooling season will also provide some shading during the heating season. For example, equivalent sun angles occur in September and March, at the fall and spring equinox. An overhang that shades a window in September - a time when you may still run air conditioning in most of the South - will also provide shade in March when the warmth of the sun is

desirable. Consequently, it is important to consider the heating and cooling needs of a house in a particular location. An overhang may be totally inappropriate on a house in a cold climate with a large passive solar heating system. The benefit during the cooling season would be offset by the reduced performance of the passive system during the heating season.

Another factor that should be considered is that overhangs only block direct solar radiation. Indirect and diffuse radiation will still cause heat gains even when a window is fully shaded by an overhang, and diffuse radiation can be a significant source of heat. The average solar radiation received in June by a window that is completely shaded by an overhang ranges from 50% to 80% of the solar radiation received by the same window without any shading. Thus, in warm sunny climates, other shading devices, such as operable shutters, blinds, or shades, should be used in addition to a fixed overhang.

There are a number of manual design tools available for sizing fixed overhangs. One method was developed by the National Association of Home Builders (NAHB). It consists of a graph that provides a value for feet of vertical wall in shade per each foot of overhang for various latitudes. The method is easy to use but has a fixed rather than user-defined shading period.

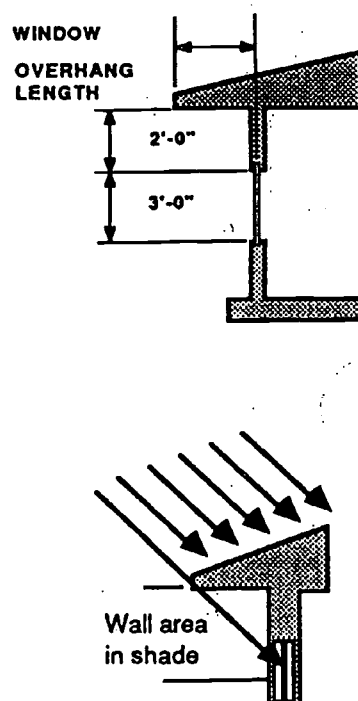


Figure 1

Example Overhang Lengths for Selected Cities in S.C.

(All values in feet of overhang)

<u>Location</u>	<u>Latitude</u>	Case 1	Case 2
		NAHB <u>Method</u> (feet)	NAHB <u>Method</u> (feet)
Aiken	33.5	2.00 - 1.45	1.25 - 2.90
Anderson	34.5	2.20 - 1.60	1.36 - 3.17
Beaufort	32.5	1.86 - 1.40	1.16 - 2.80
Charleston	32.9	1.50 - 1.90	1.20 - 3.10
Columbia	33.9	1.60 - 2.20	1.40 - 3.30
Greenville/Spartanburg	34.9	1.70 - 2.20	1.40 - 3.30
Greenwood	34.2	2.13 - 1.54	1.33 - 3.08
Florence	34.2	2.13 - 1.54	1.33 - 3.08
Myrtle Beach	33.7	2.05 - 1.47	1.28 - 2.94
Orangeburg	33.5	2.00 - 1.45	1.25 - 2.90
Rock Hill	35.0	2.29 - 1.64	1.43 - 3.28
Sumter	33.8	1.90 - 1.43	1.20 - 2.86

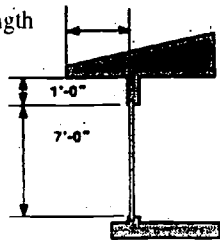
source: State Energy Office

Table 1

An example of overhang sizing is given in Table 1. The base cases consist of a sliding glass door and a conventional window with separation sizing and height of vertical south-facing glazing defined in Figure 2. Consider the recommendations for Case #1 in Columbia. The NAHB method results in a range of overhang lengths of 1.6 to 2.2 feet. This method focuses on keeping the house cool in the summer.

Case 1

Sliding Glass Door
Overhang Length



Case 2

Window
Overhang Length

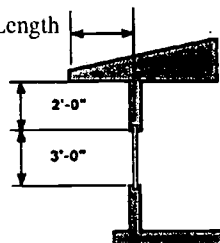


Figure 2

Because of the physical requirements of the building itself as well as aesthetic considerations, an overhang much longer than two feet is rarely justified. Also, a very long overhang may block desired solar heating in the winter and may not offer the best

protection from summer heat gain. Keep in mind that because of substantial diffuse sun, other shading devices are needed in addition to an overhang for reduction of heat caused by summer sun.

Figure 3 provides a simplified method of calculating shading requirements on south-facing glazed areas. The graph determines the feet of vertical wall in shade at noon on August 1 (summer) and February 1 (winter) per foot of overhang. To use the chart for a particular

location, pinpoint where the latitude of the location intersects the heavy curved lines. The values beneath these points are the number of feet of wall in shade for each foot of overhang in the winter and summer.

Values for the latitude, 33.9 which is Columbia, are marked on Figure 3.

It is important to note the amount of shade cast by each foot of overhang in the winter, approximately .6 for Columbia. This value can be used to size the separation between the bottom of the overhang and the top of the window in order to provide for maximum solar gain during the winter.

For example, a two foot overhang in Columbia would permit a window to be placed within the wall area that is 1.2 to 7.2 feet below the overhang.

It should be noted that the different overhang lengths within the recommended range will perform differently. Longer overhangs will provide more shade than shorter overhangs, particularly in the spring and fall. The specific heating and cooling

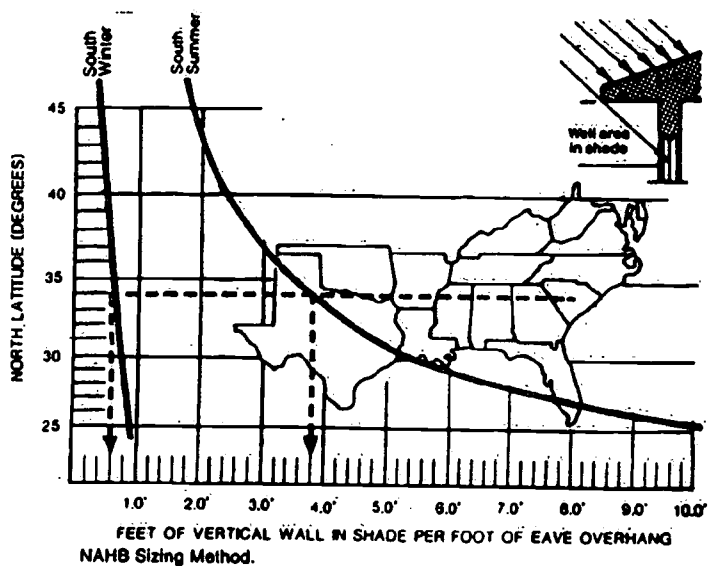


Figure 3

needs of the individual house should be considered in sizing the overhang within this range of lengths.

Sunspaces

A sunspace is a popular addition to any house. It can be used as a home heating system, a year-round garden or as extra living space. Sunlight passes through a sunspace's windows and warms the sunspace's interior. Generally, the interior surfaces include a concrete floor, brick wall, water-filled drums or some other form of storage mass. Some heat is absorbed and stored in this storage mass. When the sun sets and the sunspace's temperature drops, the storage mass slowly releases the stored heat. The heat not absorbed raises the air temperature inside the sunspace. As long as the sun shines this heat can be circulated into the house by natural convection or drawn in by a low power fan.

Five Passive Solar Elements

Sunspaces must include the following elements to be a complete passive solar heating system:

1. Collector — such as the double layer of greenhouse window glazing (glass or plastic).
2. Absorber — usually the surfaces of the walls, floors and/or waterfilled containers inside the

sunspace.

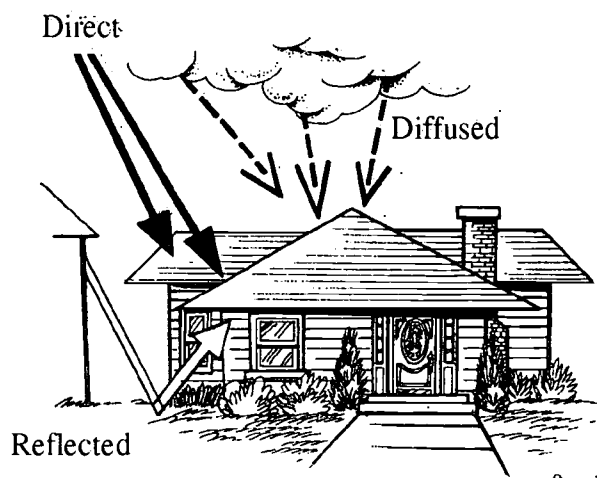
3. Storage mass — normally the concrete, brick and/or water that retains heat.

4. Distribution system — the means of getting the heat into and around the house; for example, fans and natural convective flows.

5. Control system (or heat regulation device) — such as movable insulation used to prevent heat loss from the sunspace at night, roof overhangs that block the summer sun, thermostats that activate fans, vents for summer ventilation, and doors and operable windows for heat transfer to adjoining rooms.

One of the more important questions to consider when designing a sunspace is how it will be attached to the house. One

option is to have the sunspace separated from the house by an uninsulated brick, block or concrete wall. This wall absorbs and stores solar heat. Some heat subsequently moves through the wall over a period of several hours. The sunspace can also be separated from the house by an insulated masonry wall if there is another form of thermal storage in the sunspace. In either case, most of the heat delivery is by natural convection through windows, doors or vents.



Another option is to have oversized windows and sliding glass doors where the sunspace is attached to the house. The primary storage mass for this sunspace design would be a masonry floor. The masonry should be at least 4 inches thick (typically, concrete slab covered with ceramic tile or brick). The floor should be left uncarpeted, carpeting prevents heat absorption.

A combination of these options may be the best approach.

Selecting sunspace glazing has become complicated in recent years due to the development of glass and plastic products that admit sunlight in a variety of ways. The conventional choice has been double-paned glass windows, or in very cold climates, triple-paned units. In addition to these options, manufacturers currently produce glazings with baked-in coatings. Some of these glazings reduce heat loss, some increase the amount of sunlight and heat that can be admitted, some reduce heat gain and some reduce only certain types of light.

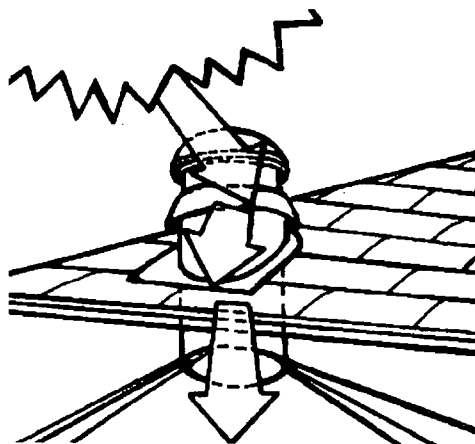
A basic rule when deciding between double glazing and coated glazing is to use ordinary double-paned glass if your sunspace is only going to be used during the day and is permitted to get cool in the evening. If you intend to spend time in your sunspace at night also, the higher quality glazings—those with special coatings—are a better choice.

The sunspace window, specially designed to easily transmit sunlight, becomes a problem when the sun sets. The loss of heat back through the glass may result in losses greater than the daytime solar gain. Movable insulation is one solution. Night insulation improves the sunspace's performance as a solar heat collector.

Results from monitoring homes indicate that well designed sunspaces can provide up to 60 percent of a home's heating requirements during the winter. The percentage depends on the square footage of the sunspace glazing, local climate, the heat requirement of the house and other design details of the sunspace/house combination.

Because your goal in the summer is to cool your house rather than heat it, your sunspace requires different maintenance at this time. Sunlight must be kept out of the sunspace, and heat that accumulates must be vented. The same movable insulation used to prevent heat loss on winter nights can be used to prevent heat gain on summer days.

Bright Idea: The Energy-Saving Sun Pipe



This 13-inch-diameter stainless steel tube, easily installed in the roof without sawing through joists or rafters, is a new, low-cost way of illuminating your home. It works (even on overcast days) by capturing and reflecting sunlight down the interior of the highly polished tube into a domed ceiling globe. The gadget provides natural light and costs nothing to operate; unlike a skylight, it does not pour unwanted heat into a room in summer or lose heat in winter. Its creator, Greg Miller, has been awarded a U.S. Department of Energy grant to further develop the device for industrial use. It is available to homeowners for \$395. For more information, write to the SunPipe Company, PO Box 2223, NorthBrook, IL 60065.

Exterior shades are more effective since they block the sun's heat before it enters the sunspace. If your sunspace has vertical windows, a carefully sized solid roof overhang will block some of the summer sun while still admitting sunlight in the winter. Retractable awnings or reflective shades are other choices. Deciduous trees, or shrubs provide shade but must be placed carefully to avoid blocking winter sun.

For venting heat, the sunspace may use an exhaust fan. Intensive use of a sunspace for growing plants significantly decreases the area's heat output. Depending on the kind and number of plants grown, evaporation from leaves can cut your sunspace's heat gain in half. A general rule is to expect your sunspace's heat output to be reduced by the percentage of floor area the plants occupy.

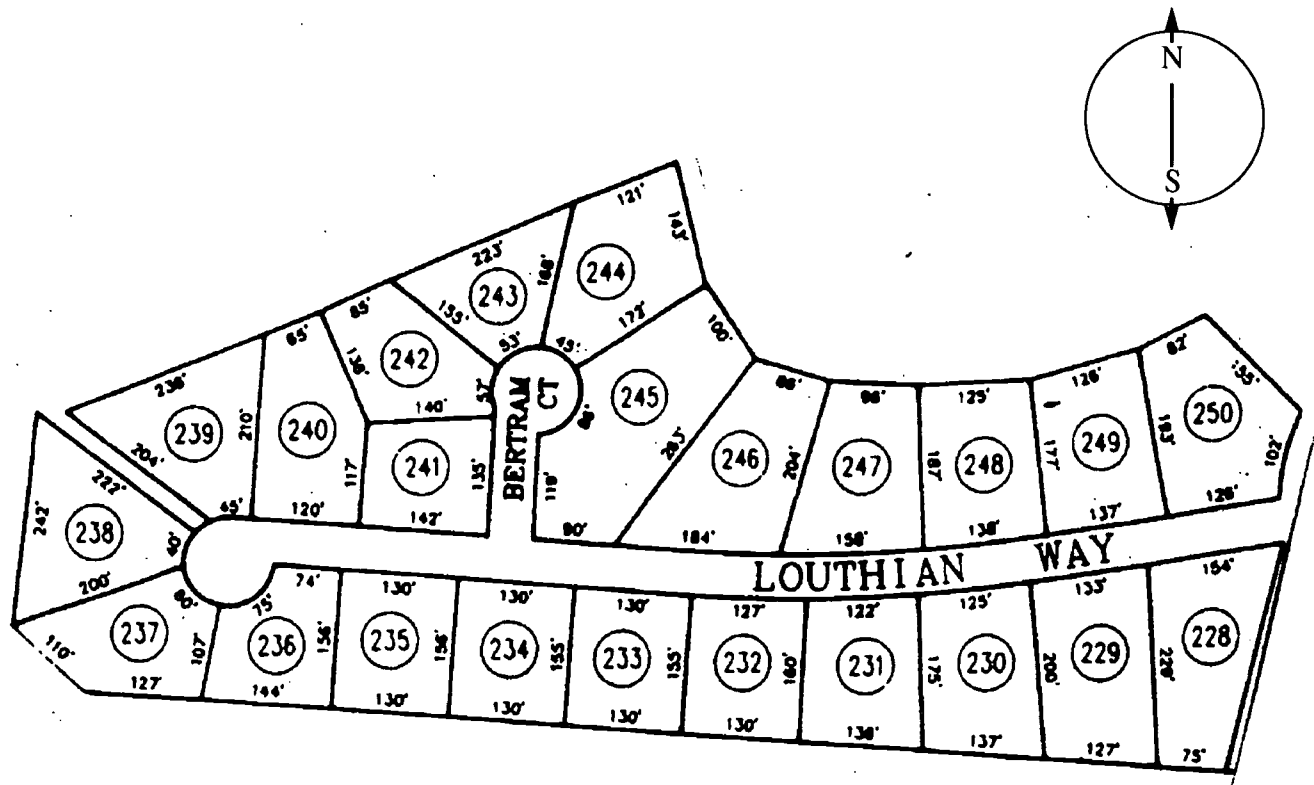
Plants can have a positive effect. They can act as natural humidifiers, making sunspace gardening especially beneficial for dry climate regions.

Many plants cannot tolerate the high temperatures and temperature swings that occur in sunspaces designed for heating. Plants in sunspaces designed primarily for heat should be limited to a small number of plants that can tolerate the high temperatures of the sunspace.

Design for Energy Efficiency

Complete this worksheet on your home selection and your ideas for energy efficiency.

Lot Selection



Study the orientation of the various lots in the neighborhood and mark your selection of a site for your home on the site plan. Draw in a box to represent how your home would sit on the lot. Note which way your home will face in reference to the sun. Your Lot Number is: _____.

Explain an energy efficient consideration for your selection:

Landscaping

On your chosen lot, indicate any trees you would plant with an "x". What type of tree (evergreen or deciduous) would you plant? Why?

Overhangs

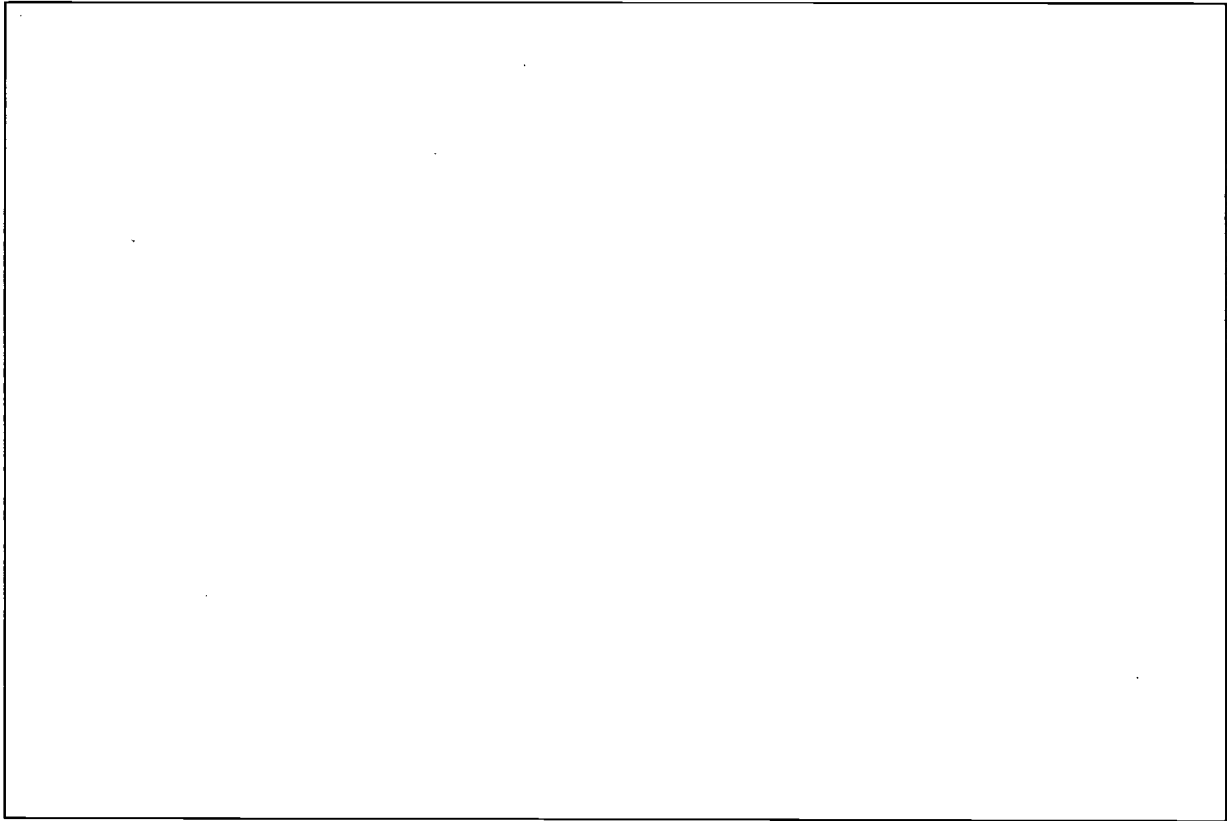
Would you use overhangs? If so, what length? On which windows? What other window treatments would you use?

Your Best Ideas for Saving Energy

Describe any special features of your home that would help it be energy efficient.

Sunspaces

Would you include a sunspace? Why or why not? Where would it be located? In the box draw a simple floor plan to show the layout of your home (label the rooms) with or without a sunspace.



RESOURCE SECTION

MYTHS AND MISPERCEPTIONS ABOUT SOLID WASTE

1. Many of the things we throw away decompose in the landfill.
(Actually, very little decomposes in the landfill because there is little air and no sunlight.)
2. When you see a recycle symbol on a product, it means that the product is recyclable.
(No. For example, the chasing arrows symbol currently on plastic items does not necessarily mean that the plastic is recyclable. It is important to know what is recyclable in your area and see that it gets recycled.)
3. When a product is advertised as "Earth-friendly," it means that it is better for the environment than other products.
(On packages and labels, terms like "Earth-friendly" are meaningless. Look for products that last, those that are reusable, those made from recycled materials, and those that are recyclable in your area.)
4. Recycling is just a fad. Recycling is a new idea that will go away.
(Before the 1920s, 70 percent of the nation's cities ran programs to recycle select materials. During World War II, industry recycled and reused about 25 percent of the waste stream. Our current national recycling rate is about 17 percent, 16 percent in South Carolina. The national and South Carolina recycling goals are 25 percent.)

Recycle

Word Search

T I O R E L C A R D B O
R R S B I A T W F E G A
A E E O Q I D N C P A R
S T V E L R M R P O R D
H T A J E G U M L S B N
R I P T C O U X A I A L
G L A S S N T U S T G R
E W H E I T I N T K E E
B L R M Z O E F I R L P
S D U P L I R E C Y C A
M L A N D F I L L B A P
A E N E R G Y T N E W S

This word search contains many recycling words that are hidden. They may be spelled forward, backward, up, down and around corners! How many can you find?

ALUMINUM

TREE

LITTER

GLASS

CARDBOARD

WATER

AIR

NEWSPAPER

RECYCLE

DEPOSIT

RESOURCE

STEEL

GARBAGE

TRASH

OIL

TIN

ORE

ENERGY

LANDFILL

Each year, Americans generate millions of tons of trash in the form of wrappings, bottles, boxes, cans, grass clippings, furniture, clothing, and much more. Over the years, we have gotten used to "throwing it away," so it's easy to understand why there's too much trash and not enough acceptable places to put it.

In the United States, we generate about 200 million tons of **municipal solid waste**, this is the garbage picked up from our homes.

In 1995, South Carolina's 3.6 million residents generated 3.8 million tons of municipal solid waste and 2 million tons of other solid wastes (industrial, construction and demolition debris, sludge, yard trash) and collected 1.1 tons of recyclables. Also, about 300,000 tons of solid waste were incinerated in solid waste combustion facilities. This gives South Carolina an average of 5.6 pounds of municipal solid waste per person per day. If all waste disposed (including industrial waste) is averaged into the equation, then each South Carolinian is responsible for about 8.5 pounds of waste per day.

As a state and a nation, we can't solve the solid waste dilemma just by finding new places to put trash.

To manage all of this trash safely and effectively, communities are using **integrated waste management systems** that combine the strategies of waste reduction, recycling, and disposal to manage waste.

The priorities of the United States Environmental Protection Agency (U.S. EPA) in its solid waste management strategy are:

- **reduce waste** by preventing its creation
- **recycle and compost** as much as possible
- **incinerate waste** or treat it in other ways to reduce its volume
- **landfill waste** as a last option.

Recyclables Collected in South Carolina 1995

<u>Recyclable</u>	<u>Tons Collected</u>
Glass	50,117
Metal	81,588
Other	514,459
Paper	125,478
Plastic	12,821
Banned Items (car batteries, white goods, motor oil)	331,270

source: 1995 South Carolina Solid Waste Management Annual Report

The U.S. EPA challenges us to reduce and recycle at least 25 percent of municipal solid waste. In 1990, South Carolina's recycling rate was about 5 percent, in 1995 it was 16 percent. South Carolina's goals are, by 1997, to reduce the amount of garbage by 30 percent and to recycle approximately 25 percent of what we would otherwise throw away.

What's In Our Garbage Can (percentage by weight)

	<u>SC Averages</u>	<u>National Averages</u>
Plastics	11%	8%
Paper	33%	40%
Glass	7%	7%
Organics	36%	25%
Inorganics	10%	9%
Other	4%	11%

The solid waste stream characterizations include residential, commercial, industrial, agricultural, governmental, and all other solid wastes that are disposed in municipal solid waste landfills.

source: 1993 South Carolina Solid Waste Management Plan

Americans produce nearly three times more solid waste annually than many other countries, and we throw most of it away.

Tips for Reducing Solid Waste from the U.S. EPA

Reduce ...

1. Reduce the amount of unnecessary packaging.
2. Adopt practices that reduce waste toxicity (harmfulness.)

Reuse...

3. Consider reusable products.
4. Maintain and repair durable products.
5. Reuse bags, containers and other items.
6. Borrow, rent or share items used infrequently.
7. Sell or donate goods instead of throwing them out.

Recycle...

8. Choose recyclable products and containers and recycle them.
9. Select products made from recycled materials.
10. Compost yard trimmings and some food scraps.

Respond...

11. Educate others on source reduction and recycling practices. Make your preferences known to manufacturers, merchants and community leaders.
12. Be creative – find new ways to reduce waste quantity and toxicity.

Did You Know...

Congress approved the U.S. EPA's 1995 budget at \$7.25 billion, a 9.5% increase compared to 1994.

WHAT IS SOUTH CAROLINA DOING ABOUT SOLID WASTE?

South Carolina has comprehensive laws and regulations to protect the environment. The 1976 S.C. Code of Laws includes the Litter Control Act, the Pollution Control Act, the Mining Act, and other regulations. **The South Carolina Solid Waste Policy and Management Act**, signed into law on May 27, 1991, is designed to:

1. Protect public health and safety, to preserve the environment of the state, and to recover resources that have usefulness
2. Establish and maintain a cooperative program to help local governments with solid waste management
3. Require local governments to plan for and provide efficient, environmentally acceptable solid waste management services and programs
4. Promote the establishment of resource recovery systems that preserve and enhance the quality of air, water, and land resources
5. Ensure that solid waste is transported, stored, treated, processed, and disposed in a manner that protects human health, safety, and welfare, and the environment
6. Promote the reduction, recycling, reuse, and treatment of solid waste, and the recycling of materials that would otherwise be disposed as solid waste
7. Encourage local governments to promote efficient

and proper methods of managing solid waste

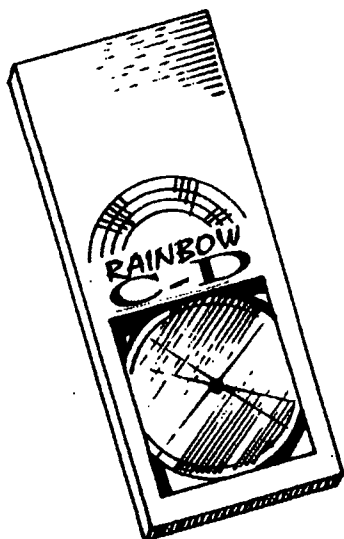
8. Promote the education of the general public and the training of solid waste professionals to reduce the generation of solid waste, to ensure proper disposal, and to encourage recycling
9. Encourage waste reduction and recycling programs through planning and technical assistance, grants and other incentives
10. Encourage the development of the state's recycling industries by promoting markets for recycled items
11. Establish a leadership role for the state in recycling efforts by requiring state agencies to recycle and by encouraging state purchase of recycled goods
12. Require counties to develop and implement source separation, resource recovery, or recycling programs or improve existing programs so that valuable materials may be returned to productive use, energy and natural resources conserved, and the useful life of solid waste management facilities extended
13. Require local governments and state agencies to determine the full cost of providing storage, collection, transport, separation, treatment, recycling, and disposal of solid waste in an environmentally safe manner
14. Encourage local governments to pursue a regional approach to solid waste management.



No Where is Away

Most Americans have grown up with the idea that when we place trash in our garbage cans, it magically disappears and we no longer need to be concerned about it. But times have changed, and the garbage we *throw away* doesn't go away. It is causing our landfills to fill up and – if not handled properly – it pollutes our environment.

We must take responsibility for our garbage. Each citizen, community, state and nation must address this social and environmental problem.



What is Source Reduction?

Source reduction means reducing the amount of waste that each of us creates. Ways to do this are to buy less, reduce packaging, and extend the useful life of products.

Besides limiting the amount of waste we produce, source reduction also reduces the overall toxicity of waste created.

An example of how awareness leads manufacturers to produce better packaging is the change in compact discs. In 1990, 20 million tons of CD-related garbage were tossed out. This garbage was caused by the long box used to package CD's. In 1991, manufacturers redesigned CD packages to reduce waste.

Source reduction conserves resources and energy, reduces pollution, and helps cut waste disposal and handling costs. *(It avoids the costs of recycling, composting, landfilling, and incineration.)*

Source reduction is a basic solution to garbage: less waste means less of a waste problem.

Precycling is a term often used along with source reduction. Precycling means reducing the volume of waste at the source by buying items that can be reused or have minimal packaging.

By realizing that purchases relate directly to waste disposal, consumers can reduce waste before it enters the home or school. Both manufacturers and consumers can practice precycling.

Precycling by the manufacturer means creating products that are durable and easily repaired. Also manufacturers can limit the amount of packaging used and can opt for packaging that can be recycled. Packing is the number one component of the nation's waste stream.

While packaging's main purpose is to protect and contain a product, it also prevents tampering, provides information, and preserves freshness. Some packaging, however, is designed largely to sell the product.



Keep in mind: as the amount of product in a container increases, the packaging waste per serving usually decreases.

At the grocery store, there are many examples of excessive packaging. We can precycle by buying items in bulk and then dividing them into smaller servings at home using reusable containers, instead of buying products packaged as "convenient single serve."

There are many arguments for and against various kinds

of packaging, this makes it very confusing for consumers to make wise choices. **Because each person throws away 440 pounds of packaging each year, the subject of overpackaging is important enough to spend time sorting out the issues.**

No one type of packaging is always correct and each product should be considered individually. However, there are certain trends in packaging that lead to more package waste than others.

Many non-food items tend to be overpackaged. One quick way to determine if a product is overpackaged is to count the separate layers that surround the item. Considering the amount of packaging needed to preserve and protect the item, there are few products that actually need more than one or two layers.

Often, the less essential a product is, the more it tends to be overpackaged, so counting the layers of waste helps identify wastefulness in more ways than one.

Another consideration of wastefulness is the useful life of a package - whether it is refilled, or used briefly and discarded. Refillable containers really are "waste fighters." Today some farm chemical containers, bottled drinking water, cosmetic bottles, and laundry detergents are sold in refillable packages.

Try to learn about the basic material found in a package. Is the resource used a renewable or a nonrenewable resource? Does it contribute to environmental pollution at the processing point?

Are there really good arguments for a particular package style? Consider that for the retailer, the package can do the following things: advertise and promote, simplify stacking and storing, preserve and protect, standardize portions and dispensing, discourage shoplifting or vandalism, and provide instructions or information.

Who pays for the cost of the package and its disposal, and who benefits most from the package? This may lead you to create a packaging solution to benefit the environment, manufacturers and consumers alike.



Reducing Toxicity
Just as important as the amount of trash you throw away is its potential harmfulness. It is important to practice source reduction and precycling to limit the toxicity of waste.

While many products containing hazardous components perform useful jobs, many tasks can be accomplished using safer substitutes.

If you need to use products with hazardous components, use only the amounts needed. Leftover materials can be shared with neighbors or donated. Never put leftover products with hazardous components in food or beverage containers.

For products containing hazardous components, read and follow all directions on product labels. When you are finished with containers that are partially full, follow local community policy on household hazardous waste disposal.

Consider Reusing

Although recycling gets a lot of attention, reusing items is the next step in waste management strategy after reducing. Reusing items conserves resources and reduces the amount we throw away. Items that are great for reuse include:

- A sturdy mug or cup used and reused in place of disposables
- Sturdy washable utensils and tableware that can be used and reused instead of plastics designed to be used once and thrown away
- Rechargeable cartridges for printers and copiers
- Cloth napkins, sponges or dishcloths used, washed and reused over and over
- Items in refillable containers, such as detergent bottles made to be refilled
- Rechargeable batteries. These also help reduce toxics in the waste stream.

Reuse Every Day

Many everyday items can have more than one use. Even keeping something out of the waste stream for a short time makes a difference. Besides these ideas, brainstorm things that can be reused at your school and at home.

Reuse paper and plastic bags and twist ties. Reuse bags the next time you shop or reuse bags as trash can liners or for other uses. If you're buying just a few items, perhaps you can skip taking a bag altogether.

Reuse scrap paper and envelopes.

Use both sides of paper before recycling it. Save and reuse gift boxes, ribbon and tissue paper.

Wash and reuse many of the plastic and glass food containers you get from the grocery store. These containers can be used to store leftovers as well as buttons, nails and thumbtacks. An empty coffee can makes a fine flower pot.

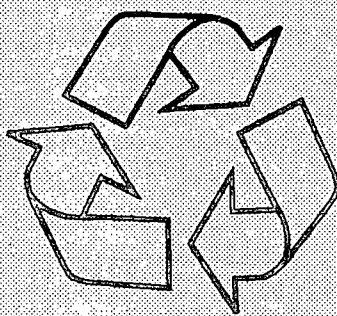
(Caution: Do not reuse containers that originally held products such as motor oil or pesticides. And never store any potentially harmful products in a reused food container.)

Keep Things Running Smoothly

If maintained properly, many products will last a long time. Long-wearing clothing, tires and appliances are less likely to wear out or break and will not have to be replaced as often.

Tips to keep things running include:

- Consider long-lasting appliances and ones that are easily repaired.
- Keep things in good working order. Properly inflated tires last as much as 10,000 miles longer than sagging ones. Check tire pressure every month.



The three arrows of the recycling symbol represent the three parts of the recycling process.

- **separating and collecting** recyclable products from the trash
- **processing** these products so that they can be substituted for virgin raw materials at manufacturing plants
- **remanufacturing** recyclable materials into useful commodities that consumers purchase.

- Mend clothes instead of throwing them away. Never throw usable clothing away. Donate it.
- Choose toys that will last.
- Consider using new low-energy fluorescent light bulbs. They last longer which means there are fewer bulbs to replace and throw out over time.

Borrow, Rent & Share

Seldom-used items often end up in the trash. Consider borrowing, renting and sharing items such as tools. It saves money and natural resources. When you can, share your newspapers and magazines with others. Many nursing homes and shelters gladly pass these items along to people who will enjoy them at least once more. Magazines are always appreciated at schools.

One Person's Trash Is Another Person's Treasure

Never throw away what might be used again. Donate used goods (in good shape) to thrift stores or other organizations that distribute them. Give hand-me-down clothes to family members, neighbors or the needy.

Choose Recyclable Products and Recycle Them

When you've done all you can to avoid waste, **recycle**. Recycling is probably the most commonly known term in waste reduction. Recycling means collecting used products and turning them into new products.

Industry has been recycling for many years. This **Preconsumer recycling** saves industry money as scrap metal, plastic, paper, and glass are recycled in the production of consumer goods. Often this material is leftover scrap or damaged goods. It has not been contaminated by other trash or mixed with other products. It also takes place on site and does not require the expense of collection and transportation.

RESOURCE SECTION 7

Postconsumer recycling is the practice of collecting materials after their use and reprocessing them into new products to be used again. According to an article in *Governing* magazine, "A Guide to Recycling," August 1994, "Recycling has become a way of life for many Americans. More than 6,500 communities pick up recyclables set out by more than 100 million residents at curbside."

Recycling technologies are changing and improving every day. An important consideration of recycling is making it economically feasible. While recycling saves energy and natural resources, it is just as important to think about the landfill space that is saved and the pollution that is prevented.

Recycling programs vary in how they are run and who runs them.

Household separation/curbside collection is usually run by municipalities and is appropriate for communities with curbside trash collection. This type of program is very convenient. Currently in South Carolina, 645,351 households have curbside collection.

Drop-off centers are the most common form of recycling in the country. In South Carolina, 646,921 households are served by 259 manned drop-off sites. These are designated collection points where people bring recyclables already sorted by type. Of the 46 counties in the state, 33 have some form of drop-off centers for recycling.

Buy-back centers operate like drop-off centers only they pay consumers for bringing in materials. Buy-Back Centers have been successful in collecting large quantities of aluminum. Businesses can recycle through commercial collection companies. These companies

collect recyclables from businesses, offices, institutions, schools and industries that generate large quantities of the same waste such as cardboard or white paper.

Choose to Participate

Our landfills are packed with many packages and products that could have been recycled.

Paper, glass, plastic, aluminum, steel, oil, and batteries are the primary targets of most recycling programs.

Get into the Recycling Cycle

Choose products made of materials that are collected for recycling locally. If your community recycles glass but not plastic,

choose glass packaging whenever you can and reuse and recycle it.

Participate in community recycling drives, curbside programs and drop-off collections. Call your local or county waste disposal officials for instructions on how to collect and separate materials. These procedures may vary from community to community.

If a recycling program does not exist in your community, participate in establishing one. Work with community officials to determine the most cost-effective recycling options for your area.

Take used car batteries and motor oil to participating collection sites. (For more on used oil recycling see the Used Oil section of this Resource.)

As more businesses and organizations provide collection opportunities, take advantage of them. For example, many grocery stores collect bags and aluminum cans for recycling.

Many businesses are getting into the recycling habit. For example, tenants of the Atrium Building in Columbia, South Carolina, have succeeded in



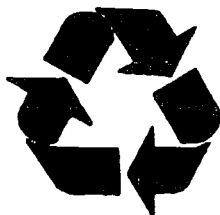
South Carolina
Department of Health and Environmental Control
Office of Solid Waste Reduction and Recycling
1-800-768-7348, 1 800 SO USE IT

developing a commercial recycling program that has cut solid waste volume by 40 percent in just one year. Businesses throughout the state are also saving money by buying recycled products such as recycled laser toner cartridges. New cartridges cost approximately \$90, while recycled ones average \$30. Recycled cartridges also last one-and-a-half times longer.

Buy Recycled

Just as the promotions to "Buy American" have gained our attention, it is important for us to remember to "buy recycled" if recycling is going to succeed as a waste management strategy. Surveys show that 9 out of 10 consumers support recycling, however, until we close the loop by increasing the purchase and manufacture of recycled content products, the solution is not complete.

To promote "buy recycled" the National Recycling Coalition has formed the Buy Recycled Business Alliance, a group of national companies that are



Bring Recycling Home

Think recycling at the cash register. When you purchase items that are produced or packaged with recycled materials, you close the loop in recycling.

- Look for recycled content by examining labels.
- Buy it back in items with recycled content such as packaging.
- Ask your stores to carry and use more products made from recycled content.
- Learn more about the thousands of recycled products and how you can make recycling work.

committed to increasing their use of recycled content products. Proving what just a fraction of American businesses can do to stimulate the market for recycled products, more than 500 large and small companies in the Buy Recycled Business Alliance spent \$10.5 billion on recycled products and materials in 1993.



Alliance companies are making an effort to increase their recycled content purchases by re-examining their buying habits and setting goals for the future. American Airlines increased the number of items it purchases with recycled content by 18 percent last year.

McDonald's Corporation reported that it has spent more than \$600 million since 1990 on recycled products including materials for carryout bags, napkins, drink trays, and towels.

The U.S. EPA and the Alliance plan a partnership program, "WasteWiSe," to encourage the business community to reduce waste at the source, collect recyclables, and to purchase and/or manufacture recycled products. For more information, call 1 800 EPA WISE or write WasteWiSe, U.S. EPA, 401 M Street, Mail Code 5306, Washington, DC 20460.

For more information on the Buy Recycled Business Alliance and its publication, *Buy Recycled Newslne*, write The National Recycling Coalition, 1101 30th Street, NW, Suite 305, Washington, DC 20007.

To spur use of recycled paper, President Bill Clinton has signed a new Executive Order on buying recycled products. Clinton's order raises the level of post-consumer content required in recycled printing and writing paper purchased by the federal government to 20 percent by the end of 1994 and 30 percent by 1998. In South Carolina, all government agencies are encouraged to purchase recycled products whenever possible and must establish a source separation and

RESOURCE SECTION 9

recycling program. The South Carolina Solid Waste Management Plan states that by November 27, 1993, the Governor's Office, the General Assembly, the Judiciary, each state agency and each state-supported institute of higher education shall establish and implement a solid waste reduction program.

Two South Carolina groups, the **Center for Waste Minimization** and the **Recycling Market Development Council**, are available to provide technical



assistance to the state's businesses on reuse and to help locate markets for recovered materials and products with recycled content. The Center for Waste Minimization helps businesses that want to use a recovered material in place of a virgin material or that want to recycle their own wastes. Market development can boost the financial return on materials, improving the bottom line of recycling programs.

What Industry Can Do Better Product Design

Changes in the design of a product or its packaging, such as making the packaging lighter in weight or smaller or offering a product in a concentrated form, can save transportation costs and packaging costs, and can reduce garbage.

Aluminum cans are a good example of light-weight packaging. Over time, manufacturers of soda cans have decreased the amount of aluminum used per can. In 1976, 23 cans were made from a pound of aluminum; today, 29 cans are made from the same amount. Today, although they retain the same strength and size, glass jars now weigh in 44 percent less than jars used 20 years ago.

Initiatives have been taken by other manufacturers. For example, General Mills reduced the thickness of the plastic bags in cereal boxes to decrease the amount of plastic the company used annually by 500,000 pounds. Procter & Gamble eliminated the packaging for Secret and Sure deodorants, thereby removing about 80 million cartons a year from the waste stream.

Other things that companies can do are to incorporate environmental business policies. For example, offices with high reproduction budgets may consider establishing a double-sided copying policy. After instituting such a policy for client documentation, AT&T estimated that if this policy is followed only 50 percent of the time, the amount of paper used will be reduced by 77 million sheets annually and company costs will decrease by \$385,000 a year.

A groundbreaking program to educate the next generation of engineers and product designers to be sensitive to the needs of the environment is taking place the School of Engineering at Grand Valley State University in Michigan. The university is incorporating a concept called Design for Recycling introduced by the Institute of Scrap Recycling Industries, Inc. The project's aim is to foster the design and manufacture of goods that can be recycled safely and efficiently at the end of their useful lives.

Many other universities are incorporating recycling technology and waste management study into their curriculum offerings.

A Consumer's Guide to Environmental Claims in the Marketplace

Excerpts from marketing information provided by Scientific Certification Systems, a leading independent organization certifying manufacturers' environmental claims.

There's no doubt about it. More companies than ever before are considering the environmental implications of the products they produce. And more products than ever carry environmental claims.

- 1) All products have an impact on the environment. Every product involves the use of resources and energy at some point in its production, use, or disposal. Solid and hazardous wastes may also be generated. Watch out for vague claims like "environmentally friendly" and "safe for the environment." Also be on the lookout for environmentally suggestive packaging which may leave a strong impression but doesn't add up to much.
- 2) Specific claims are best. Recycled content claims should always indicate an actual percentage.
- 3) Significant achievements deserve recognition. Not every environmental claim represents an improvement. Some companies have resorted to making irrelevant claims. What about a product that advertises "no CFCs" when CFCs have not been allowed for 15 years? Or what do they mean by "landfill safe?"
- 4) Claims should be verified. Every company should be able to provide detailed documentation to support the claims they make.



The Benefits of Composting

While many of us see composting as a new idea, it isn't. The Roman Statesman Marcus Cato introduced composting as a way to build soil fertility throughout the Roman Empire more than 2,000 years ago.

Backyard composting of certain food scraps and yard trimmings can significantly reduce the amount of waste that needs to be managed, landfilled or incinerated.

In South Carolina the Solid Waste Policy and Management Act prohibits counties from disposing of yard wastes and land-clearing debris in municipal solid waste landfills after May 27, 1993. Currently there are about 26 registered composting and wood chipping/shredding facilities in the state.

Yard wastes must be handled separately. This means that yard wastes do not belong in the trash. Many communities will still offer curbside pickup of these wastes in special containers so that they can be taken for composting or shredding.

Nature's Recycling

Composting is the natural process of decomposition and recycling of organic material into a rich soil amendment known as compost. When properly composted, yard wastes and some food scraps can be turned into natural soil additives for use on lawns and gardens and used as potting soil for house plants. Finished compost can



improve soil texture, increase the ability of soil to absorb air and water, suppress weed growth, decrease erosion and reduce the need for soil additives.

Just as an aluminum can is a valuable resource, so are yard clippings. And yard clippings and food wastes make up about 25 percent of our household waste.

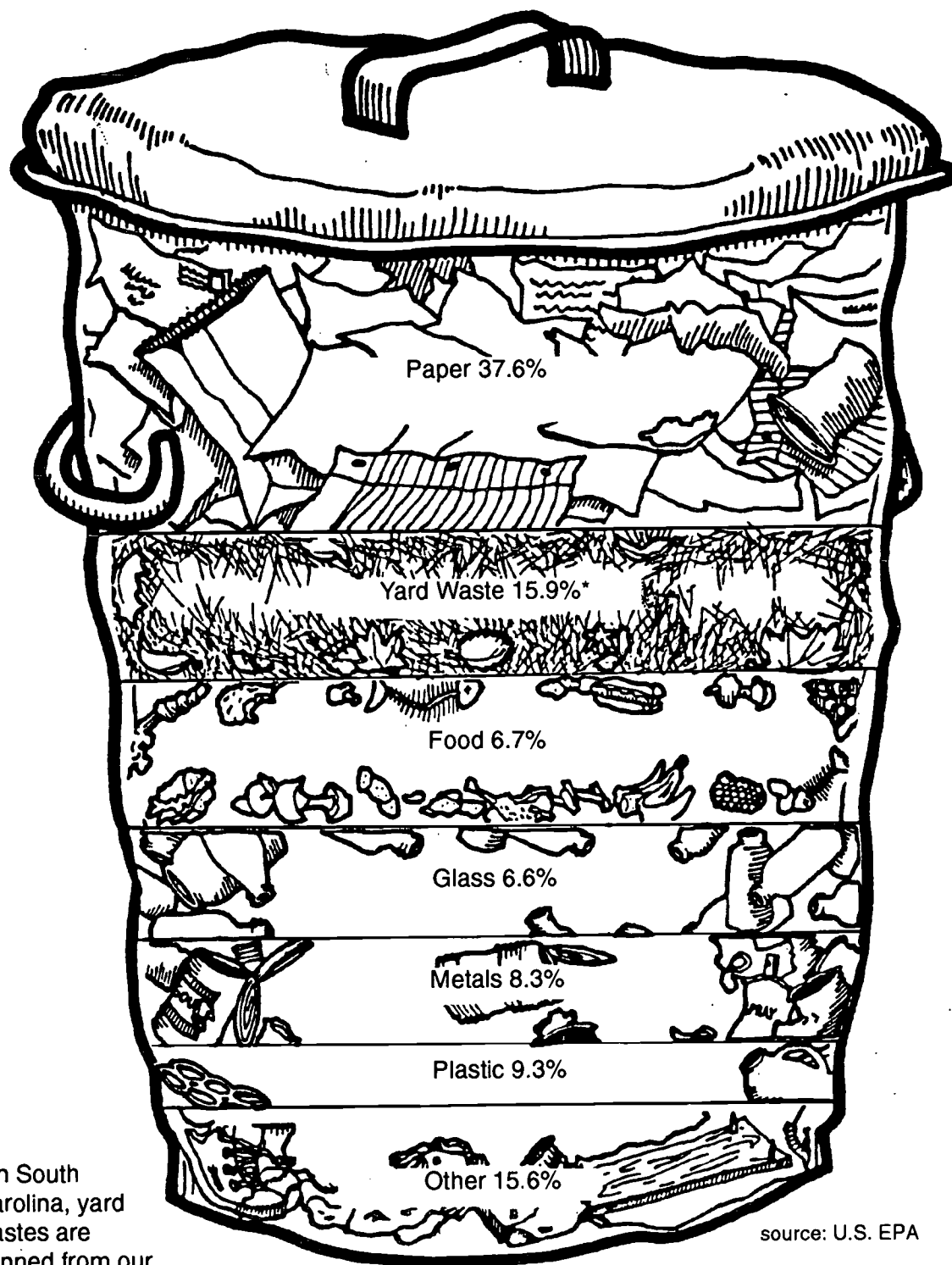
Some people think that composting takes too much time. If you are composting yard clippings, you will only spend about five minutes each week maintaining your compost pile, figure in a few extra minutes if you are including kitchen scraps.

A simple way to compost yard wastes is to allow mown grass clippings to remain on the lawn to decompose and return nutrients back to the soil, rather than bagging and disposing of them.

“If you are thinking a year ahead, sow a seed.
If you are thinking ten years ahead, plant a tree.
If you are thinking one hundred years ahead, educate the people.”

These words from a Chinese poet, 500 BC, echo the task ahead as our country works to educate its people about the environment and the role we each play in protecting it. Share information about source reduction, recycling, and composting with others. Write to companies and let them know your preferences for products and packaging that reduce solid waste.

What's in Your Garbage Can?



* In South Carolina, yard wastes are banned from our landfills.

source: U.S. EPA

RESOURCE SECTION 13

SARAH CYNTHIA SYLVIA STOUT WOULD NOT TAKE THE GARBAGE OUT

Sarah Cynthia Sylvia Stout
Would not take the garbage out!
She'd scour the pots and scrape the pans,
Candy the yams and spice the hams,
And though her daddy would scream and shout,
She simply would not take the garbage out.
And so it piled up to the ceilings:
Coffee grounds, potato peelings,
Brown bananas, rotten peas,
Chunks of sour cottage cheese.
It filled the can, it covered the floor,
It cracked the window and blocked the door
With bacon rinds and chicken bones,
Drippy ends of ice cream cones,
Prune pits, peach pits, orange peel,
Gloppy glumps of cold oatmeal,
Pizza crusts and withered greens,
Soggy beans and tangerines,
Crusts of black burned buttered toast,
Gristly bits of beefy roasts...
The garbage rolled on down the hall,
It raised the roof, it broke the wall...
Greasy napkins, cookie crumbs,
Globs of gooey bubble gum,
Cellophane from green baloney,

Rubbery blubbery macaroni,
Peanut butter, caked and dry,
Curdled milk and crusts of pie,
Moldy melons, dried-up mustard,
Eggshells mixed with lemon custard,
Cold french fries and rancid meat,
Yellow lumps of Cream of Wheat.
At last the garbage reached so high
That finally it touched the sky.
And all the neighbors moved away,
And none of her friends would come to play.
And finally Sarah Cynthia Sylvia Stout said,
"OK, I'll take the garbage out!"
But then, of course, it was too late...
The garbage reached across the state,
From New York to the Golden Gate.
And there, in the garbage she did hate,
Poor Sarah met an awful fate,
That I cannot right now relate
Because the hour is much too late.
But children, remember Sarah Stout
And always take the garbage out!

Shel Silverstein - Where the Sidewalk Ends

Hey...
Sarah Cynthia, What about recycling
and composting? This way there's a
lot less garbage to take out.

A Guilt-Free Guide to Garbage

Excerpts from *Consumer Reports* magazine, February 1994

Global warming and the thinning ozone layer are abstract threats that make many consumers feel helpless. Garbage however, brings environmental issues close to home. Spurred by public concern and local regulations, consumers are dutifully filling recycling bins, buying products made of recycled materials, and avoiding wasteful packaging.

RECYCLING

IS IT WORTH THE EFFORT?

"In the first week in November 1992, more adults took part in recycling than voted," says Jerry Powell, editor of *Resource Recycling* magazine and chair of the National Recycling Coalition.

Clearly, recycling has taken hold.

Recycling does help keep garbage out of landfills and incinerators, both of which pose environmental problems. But recycling has its limitations. It will never fully replace other methods of garbage disposal. Moreover, the greatest problems with landfills and incinerators come from the disposal of toxic metals and hazardous wastes – and so far recycling has done little to solve those problems.

Recycling's greatest advantage may not be at the dump, but at the factory. Making new products out of recycled materials almost invariably produces less air and water pollution, and uses up much less energy, than making the products out of virgin material.

On the national level, recycling is becoming more cost-effective as garbage disposal becomes more expensive. New regulations from the U.S. Environmental Protection Agency set strict guidelines on how and where landfills can be built.

These regulations will raise the price of sending trash to landfills – not only because new landfills are costly to build, but because many old ones will be shut down. According to one recent estimate, about 20 percent of all the country's landfills may have to close under the new regulations.

DOES RECYCLING PAY?

While American cities and towns have increasingly looked to recycling programs as an option, they have often found that the economics of recycling works against them.

First, there's the initial investment in extra trucks and sorting equipment and the cost of paying people to run them. Picking up recyclables costs more than picking up the same quantity of trash. Most municipalities collect their materials comingled, that is, jumbled together in one bag or bin. These eventually make their way to a Materials Recovery Facility, or MRF, where recyclable materials are sorted and sent on to brokers or directly to the factories that will use them. With their heavy machinery and their dependence on hand-sorting materials such as paper, plastic, and glass, MRFs are expensive to build and to run.

Together the costs of pickup and processing easily outstrip the current value of recycled material. A widely quoted study by Waste Management of North America Inc., the nation's largest private garbage hauler and landfill operator, found that the company spends an average of \$175 a ton to pick up and sort the recyclables that most communities include in their curbside programs – glass, aluminum, steel cans, newspaper, and plastic – but receives only \$40 a ton for them.

REPLACING RAW MATERIALS

"The problem with throwing away a ton of cardboard is not that it's going to hurt somebody if you burn it or bury it," says John Schall, an environmental economist. "The problem is that you have to make the next ton of cardboard by cutting down trees, which has immensely greater environmental impact than disposing of it."

RESOURCE SECTION 15

Many analysts have now compared the environmental impact of using virgin raw materials versus the environmental costs of collecting, sorting, and remanufacturing recycled materials. In almost every case, using recycled materials has substantial environmental benefits.

An analysis done by the Tellus Institute, a Boston environmental consulting group, found that a major benefit of using recycled materials is that it saves energy. And energy use is responsible for the major environmental impacts of production: the depletion of nonrenewable resources, the air pollution, the generation of greenhouse gases that may contribute to global warming, and so on.

If using recycled materials makes so much sense, why haven't manufacturers been doing it all along? In some cases, they have. The aluminum industry discovered the economies of recycling two decades ago, and tissue, cardboard, and boxboard manufacturers have used scrap paper for years. Recycling is built into the steel industry. One of the two major types of steelmaking furnace must have 25 to 30 percent scrap metal to function properly; the other type runs on 100 percent scrap.

Nevertheless, most manufacturing industries are still geared to run on virgin rather than recycled materials, driven by the abundance and low cost of virgin resources in the US.

Factories have a huge infrastructure designed to use virgin materials, and retooling to use recycled materials can be very expensive. When a Canadian newsprint manufacturer, decided to equip its mill to use more than 50 percent recycled pulp, it spent \$50-million in Canadian dollars to build an immense new de-inking plant. Union Carbide Inc., one of the nation's suppliers of plastic, had to build a new \$10-million factory to recycle bottles made from plastic that it had produced in the first place.

Recently, a consortium of American companies, including Time Inc., the Prudential Insurance Company, Johnson&Johnson, and McDonald's

Corp., announced that they were banding together with the encouragement of the Environmental Defense Fund, to increase their own use of recycled paper and to encourage other companies and institutions to follow suit. This effort should get the paper industry's attention: The participating organizations buy more than \$1-billion worth of paper and paper products each year.

The next wave in recycling may be spurred by legislation. Many states have passed laws specifying recycled content for newspapers. Last October, a White House executive order required the Federal Government to use only paper that is at least 20 percent recycled fiber. Though the Government accounts for only 2 percent of the total printing and writing paper market, the order is expected to set a de facto standard for similar public and private initiatives, and thus promote the national effort to recycle paper.

THE BEST SOLUTION: USE LESS

A key part of environmental planning is what's being called "source reduction" – design or purchasing choices that reduce the amount of materials used. Many manufacturers have begun selling their products in a form that minimizes packaging. Concentrates of products from fruit juice to laundry detergent have proliferated on supermarket shelves in recent years.

Because all forms of trash disposal – including recycling – have environmental impacts, the best thing a consumer can do is to avoid buying new things whenever possible. When you need to buy, you can practice source reduction by shopping for products that have as little packaging as possible. The next step is to buy products made from recycled content. "The only true recycler is someone who uses recycled products," says Jerry Powell, editor of *Resource Recycling*. Finally, it is important to recycle whatever you can in your community – and do it right.

Does Environmentalism Cost?

—excerpts from GreenWatch,
Good Housekeeping, Feb. 1993

Traditional thinking is that the environment and the economy are inevitably at odds, that whenever environmental conservation or cleanup takes place, it results in an overall loss of jobs and income. But today, two decades after environmental laws came into play in the United States, there is abundant evidence that virtually all aspects of environmentalism – from pollution control to energy conservation to land preservation – create economic growth.

Since the early 1970s, the U.S. environmental cleanup business has grown at a remarkable 20 percent per year, even during recession, to create two million new jobs in 65,000 new firms with annual sales in 1991 of \$130 billion.

“We’re in a time of transition not unlike the time our economy changed from horse-driven to engine-powered,” says Michael Silverstein, president of Environmental Economics, a Philadelphia consulting firm.

Once-polluting companies often reap the economic benefits of environmental clean-up themselves as their operations become more efficient. A low polluting firm, by definition, is a firm that makes efficient use of its energy and raw materials. By

doing just that, firms ranging from IBM to Dow Chemical have cut costs and increased profits. DuPont, for example, reports annual savings of \$50 million with its new waste-recovery facilities.

Most important of all, environmental laws and consumer preferences for nonpolluting products have given rise to creative technologies needed to keep the U.S. competitive in the growing \$370 billion world market for green goods and services.

A POLL COMMISSIONED BY
TIME MIRROR MAGAZINES
IN 1992 REVEALED THAT
64 PERCENT OF AMERICAN
ADULTS INTERVIEWED SAID
ENVIRONMENTAL
PROTECTION WAS MORE
IMPORTANT THAN ECONOMIC
GAIN.

Where the Jobs Are

Green professions are in demand. Manufacturing, production and management strategies are being revamped. Companies are examining every aspect of business from the extraction of raw materials to the disposal of the final product. This includes purchasing, public relations, marketing, financial management, research and development, accounting, sales, personnel, training and strategic management.

1. Environmental consultants are regularly called in when companies are making transitions
2. Banks need environmental investors and researchers
3. Nonprofit organizations provide careers in public interest foundations, think tanks, labor unions and trade associations.
4. Environmental services are needed to promote pollution control and waste management. Businesses are needed to create new technology for clean-ups.
5. The petroleum industry needs environmental engineers, biologists and consultants to perform studies on the environment.
6. Chemical firms also need environmental engineers as well as compliance administrators and product and marketing managers.
7. Organic foods have created a niche in industry. Experts are needed for pest management, organic gardening, retailing of organic food and mail order sales.
8. Environmental lawyers are needed.
9. Insurance companies have had to acquire the cost of cleaning up wastes left by firms carrying their policies. Environmentally aware underwriters are necessary.

These are just a few examples of the edge given to those in the job market that are environmentally educated. There are many more.

Source: *Environmental Careers: A Practical Guide to Opportunities in the '90s*, Lewis Publishers.

RECYCLING PROS AND CONS

Not everything can be recycled easily. Here's a rundown of the different materials that consumers recycle in typical curbside programs.

PAPER

37.5 percent of municipal solid waste

38 percent recycled

Advantages

Recycling paper saves more landfill space than recycling any other material.

Recycling reduces air and water pollution.

Many recycled-paper mills being developed.

Abundant supply of newspaper and cardboard.

New recycling plants can take magazines.

Cheapest of all materials to sort.

Obstacles

Weak markets for mixed paper.

Recycled paper of lower quality than virgin paper for some uses.

Cannot be recycled indefinitely.

Photocopy, laser-printed paper hard to de-ink.

De-inking plants costly to build.

Overview

Paper shows what can happen with a combination of market incentives and good technology.

PLASTIC PACKAGING

3.6 percent of municipal solid waste

6.5 percent recycled

Advantages

Recycling reduces air pollution.

Recycling helps conserve oil and gas.

Obstacles

Nonpackaging plastic is rarely recycled.

Only PET and HDPE recycled in quantity.

Cannot be recycled indefinitely.

Generally not recycled into food containers.

Light weight makes it expensive to pick up.

Automatic sorting equipment expensive.

Some virgin plastics available cheaply.

Some resins difficult to clean adequately.

Overview

Plastics recycling is turning out to be the most difficult to achieve.

CONTAINER GLASS

6.1 percent of municipal solid waste

33 percent recycled

Advantages

Recyclable containers make up 90 percent of discarded glass.

Can be recycled indefinitely.

Can be recycled into food containers.

Labels, food residues burn off in furnaces.

Steady markets for clear and brown glass.

Obstacles

Bottles break during sorting.

Broken glass hard to reuse.

Must be hand-sorted by color.

Poor markets for green glass.

Often contaminated with unusable glass.

Overview

New uses and markets are needed for mixed color and broken glass.

RECYCLING PROS AND CONS

As more and more communities offer recycling, these statistics will change. A steady stream of recycled materials for processing and consumers eager to "buy recycled", encourage industry to invest in manufacturing processes that use recycled materials instead of raw materials.

STEEL CANS

1.5 percent of municipal solid waste

41 percent recycled

Advantages

Recycling reduces pollution, conserves ore.

Can be recycled indefinitely.

Can be recycled into food containers.

Dirt and contaminants burn off in furnaces.

Easy to separate with magnets.

Steel mills already set up to use scrap steel.

Strong market for recycled cans.

Obstacles

None.

Overview

If everything were as easy to recycle as steel, there would be no "solid waste crisis."

ALUMINUM CANS

1 percent of municipal solid waste

68 percent recycled

Advantages

Recycling uses 95 percent less energy than virgin production.

Recycling reduces pollution, conserves ore.

Can be recycled indefinitely.

Can be recycled into food containers.

Dirt and contaminants burn off in furnaces.

Well-developed structure for collection and processing.

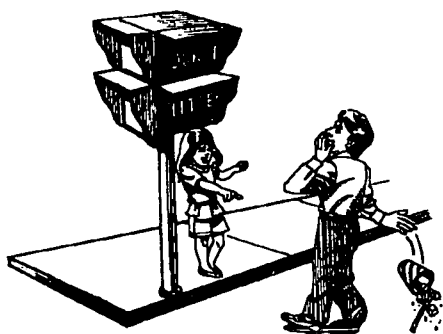
Strong market for recycled cans.

Obstacles

Light weight makes collection expensive.

Overview

The economics of energy savings made aluminum the first large-scale recyclable and the most valuable recyclable material.



TAKE THE POLLUTION TEST!

- If you walked somewhere, rode your bicycle, or rode public transportation – the bus – (instead of using your car) in the last week, give yourself 10 points.
- If you recycle newspaper, used computer paper, and/or junk mail, give yourself 10 points.
- If you picked up litter in the past week, add 5 points. If you littered in any way, subtract 20.
- If you planted one or more trees last year, add 10 points.
- If you had someone drive you to a destination fewer than two blocks away (such as driving you to a friend's house just down the street), take away 20 points.
- If you visited a natural setting (such as the woods, a stream, or a mountain trail) in the past month, give yourself 10 points.
- If you recycle aluminum cans or foil, give yourself 10 points.
- If your family burns or bags your leaves or grass clippings, take away 10 points.
- If you compost, mulch, or leave yard waste to decompose, add 10 points.
- If your family has a compost pile, add 10 points.
- If you have ever grown a vegetable garden, add 5 points.
- If you forgot to turn off a light, television, or radio in an empty room today (did you turn off your room light before you came to school?), subtract 5 points.
- If you use both sides of a piece of paper before throwing it away, add 5 points.
- If you recycle at home or school, add 10 points.
- If you have worked to clean up the environment in the last year (participated in a paper drive, started a recycling project, picked up trash, etc.), add 10 points.
- If you recycle your used motor oil, add 5 points.
- If you choose not to buy products with excessive packaging, add 10 points.

How did you score?

90 points and above: Great! You are working hard to protect the Earth!

80 - 89 points: You are concerned for the Earth and are doing OK!

70 - 79 points: You need to make plans and try harder.

Below 69 points: STOP NOW and Take Action in your family to prevent pollution!

A Closer Look At Glass

Glass is an ideal material for reuse. Each person in the United States uses almost 400 bottles and jars each year, and none of these belong in our landfills and incinerators. Because glass takes so long to decompose, the bottle you throw away today might still be littering the landscape or taking up space in the landfill in the year 3000.

At home, some of these glass bottles and jars can be safely washed and rinsed and reused as food containers.

Although glass bottles are designed to handle up to 30 round trips from manufacturer to consumer, glass production for beverage containers is decreasing as plastics become more popular. Fewer refillable glass bottles are available.

The next best thing to reusing glass is recycling it.

According to the Glass Packaging Institute, the United States recycled 33 percent of its glass bottles and jars in 1993, up from 29 percent in 1990.

Glass can be collected, crushed into cullet, melted and used again and again. **Glass is 100 percent recyclable.** Glass doesn't degrade with recycling. It can last for hundreds, perhaps thousands of years.

Although the raw materials from which glass is made are plentiful, their collection and transformation into glass require a large amount of energy. It takes about 7,600 Btus of energy to produce just one pound of glass. Along with the production of one ton of glass come nearly 400 pounds of mining wastes and 28 pounds of air pollution.

To make glass using recycled glass, the used glass or crushed cullet is mixed with the raw materials of sand, soda ash and limestone. The mixture is heated in a furnace at temperatures of up to 2,800° F. Using cullet saves energy because it melts at lower

temperatures than that required to produce glass from raw materials. For each 10 percent of cullet used, the furnace can be lowered 10° F.

Glass can be made from as much as 93 percent recycled glass. Using one ton of recycled glass saves 1.2 tons of raw materials. According to one estimate, by using 50 percent recycled glass in manufacturing new glass, water consumption can be cut in half, mining wastes cut by 70 percent and air emissions reduced by 14 percent.

To be recycled, glass must be separated by color – clear, amber and green. This ensures color consistency of the new container being made.

In preparing glass for recycling, it is important to remove the lid and rinse out the container. Labels do not need to be removed since they are burned off in processing. Separate glass by color. You'll want to find out which colors are recycled in your area.

Recipe for Making Glass

To make just one ton of glass:

1,330 pounds of sand
433 pounds of soda ash
433 pounds of limestone
151 pounds of feldspar
15.2 million Btus of energy

Major deposits of white sand suitable for making glass are found in Illinois, New Jersey, the Alleghenies and the Mississippi Valley.

Most soda ash comes from Wyoming, and 65 percent of the feldspar in the U.S. comes from California and North Carolina.

Different colored glass is produced by adding small amounts of other substances such as iron, copper and cobalt. Green glass is made by adding iron.

To save these resources, glass can be made from as much as 93 percent recycled glass.

RESOURCE SECTION 21

In recycling glass, it is critical not to recycle Pyrex glass, ceramics, plates or drinking glasses, light bulbs or mirrors. A single piece of these materials can contaminant a large load of recyclable glass.

Other Uses For Recycled Glass

Emerging

According to the Glass Packaging Institute, a growing number of secondary markets are emerging for mixed-color or off-spec cullet. This cullet can be used for a replacement for gravel and crushed stone in road base construction, pipe backfill and storm drains; and as an ingredient in a form of asphalt, known as "glasphalt." Mixed cullet is also used to a limited degree in the fiberglass insulation industry; in the production of reflective beads and reflective paint; and as an abrasive in sand-blasting. Today, more than 95 percent of the U.S. residential curbside collection programs include glass. Obstacles to glass recycling are that it can break during collection and transport (broken glass is hard to reuse), it must be sorted by color, and even small amounts of unsuitable glass can contaminant an entire load.

More About Glass

The energy saved from recycling one glass bottle will light a 100-watt bulb for four hours.

Every ton of crushed waste glass saves the equivalent of about 30 gallons of oil.

Glass Recycling in Europe - 1991

Country	Collected volumes (tons)	% Recycled
Austria	223,000	60%
Belgium	60,000	55%
Denmark	15,000	35%
Finland	987,000	31%
France	2,295,000	41%
Germany	26,000	63%
Greece	16,000	22%
Ireland	763,000	23%
Italy	360,000	53%
Netherlands	10,000	70%
Norway	50,000	22%
Portugal	310,000	30%
Spain	57,000	27%
Sweden	199,000	44%
Switzerland	54,000	71%
Turkey	385,000	28%
United Kingdom		21%
Total	5,966,000	46.3%

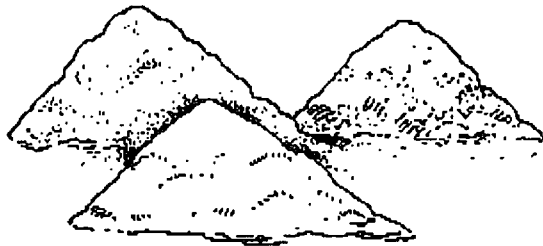
Note: According to the Glass Packaging Institute, the United States recycled 33 percent of its glass bottles and jars in 1993, up from 29 percent in 1990.

source: Warmer Information Sheet

New Glass Technologies

According to a newsletter by the Warmer Campaign, funded by the World Resources Foundation, techniques have been pioneered in the United States to cover clear glass with colored coatings which, when the glass is being recycled, simply dissolve. If all glass were manufactured clear and then colored in this way, instead of the integrated green and amber coloring at present, there would be no limit to the amount of cullet that could be reused in the production of new containers. Best of all, there would be no need to sort glass for recycling.

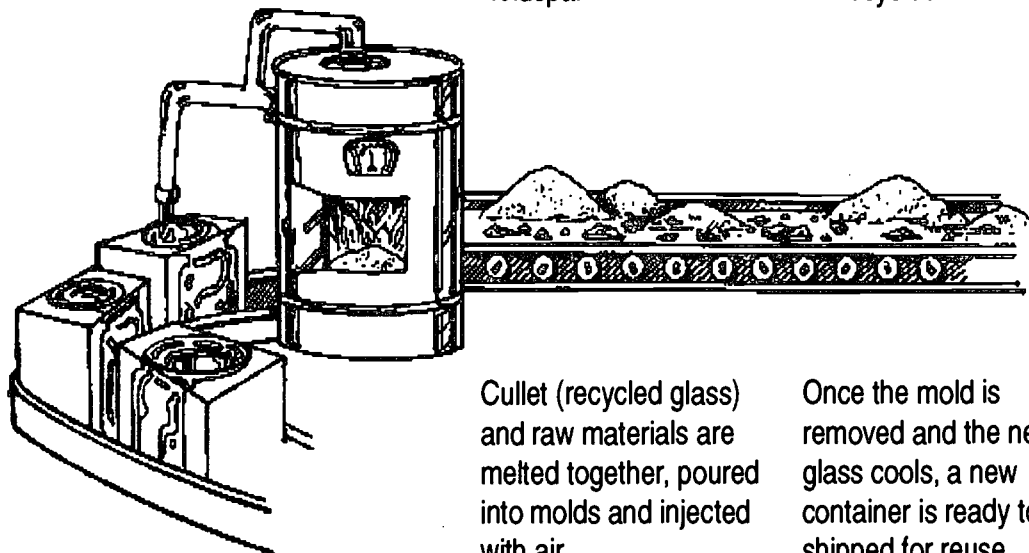
Glass Manufacturing



Raw Materials:
sand, soda ash, limestone,
feldspar

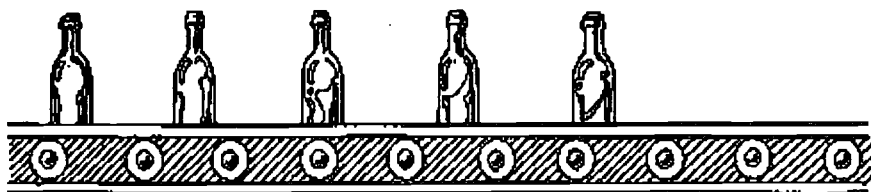


Recycled Materials:
cullet or glass to be
recycled



Cullet (recycled glass)
and raw materials are
melted together, poured
into molds and injected
with air.

Once the mold is
removed and the new
glass cools, a new
container is ready to be
shipped for reuse.



Take A Closer Look At Paper

Since 37.6 percent of everything we throw away is paper, recovering paper helps ease the burden on our overcrowded landfills.

Today most paper comes from trees. However, before 1850, paper in the United States was made from recycled fibers from rags and waste paper. From 1690 when the first paper mill was built near Philadelphia to 1850 when wood replaced rags and waste, paper mills were large recyclers.

After the switch from rags to wood, paper mills continued recycling old waste paper as part of the manufacturing process. In 1916, the United States produced 15,000 tons of paper a day and used 5,000 tons of waste paper in the process, a 33 percent recycling rate.

Today, the United States is the largest producer and consumer of paper and paper products in the world.

Wood that is unsuitable for use as lumber and lumber mill wastes are used to make paper. According to some experts it takes the equivalent of 17 trees to make one ton of paper, however the Paper Information Center of the American Paper Institute says that it is inaccurate to suggest that it takes a specific number of trees because trees come in a variety of sizes. The Center also says that, in large measure, trees harvested for paper were planted for that purpose. They also note that U.S. papermakers obtain over half their raw material from waste products — waste wood, such as chips and sawdust, and recovered paper.

Many large pine forests in the Southeast are grown and harvested for paper. Paper mills are generally located near the source of trees to save transportation costs. About 35



percent of the world's annual commercial wood harvest is used to produce paper, and this share is expected to grow to 50 percent by the year 2000.

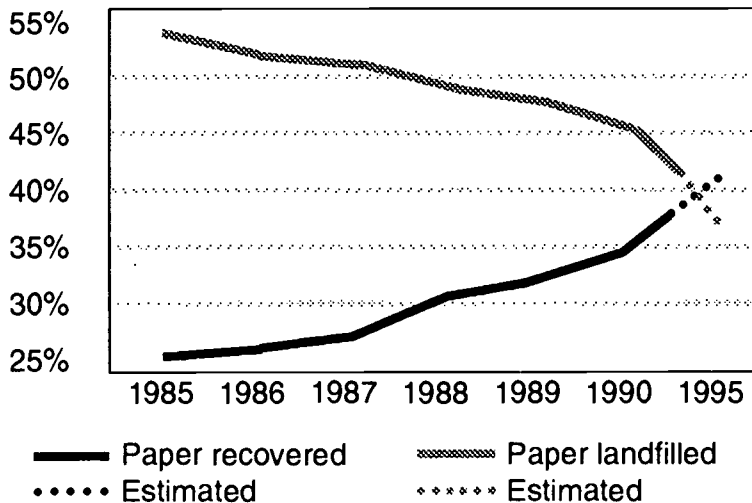
Although wood is a renewable resource, the experts do not agree on our preservation rates. Some say we are presently using more of our forest resources than we are replacing, while the American Paper Institute says the U.S. has more trees today than it did 70 years ago.

According to the U.S. Forest Service, federal tree-cutting is nearly three times greater than federal tree-planting. In the South, however, in 1989 the government cut 132,638 acres of timber and planted 127,913 acres.

In addition to depleting natural resources, manufacturing paper uses energy and creates pollution. And that doesn't include the waste that comes from the disposal of the paper itself.

Paper Recovered to Exceed Paper Landfilled

source: American Paper Institute and Franklin Associates



Why Recycle Paper?

Recycling helps extend the life of our landfills. Nearly a third of our waste stream by weight and over half by volume is paper. If we recycled half of the paper used in the world today we would meet almost 75 percent of the demand for new paper and leave nearly 10 million acres of forest standing.

Today, nearly four times more paper is being diverted from the waste stream than all other recyclable materials combined. But the best news about paper recycling is that it is growing by leaps and bounds. Two years ago, America's paper companies set an ambitious goal: By the end of 1995, recover – for domestic recycling and export – 40 percent of all the paper Americans use. The industry is pleased to report that this goal was achieved two years sooner than expected. The new paper recycling goal is 50 percent.

In 1993, more than half the newspapers published were recovered – up from a third four years earlier. About 60 percent of corrugated boxes are recycled.

A campaign is underway by the National Office of Paper Recycling to increase office paper recycling. About half of all paper is generated in the workplace and currently only about 15 percent of it is recycled. The campaign also emphasizes *closing the recycling loop* by collecting paper for recycling and purchasing recycled paper.

Executive Order Says Purchase Recycled Paper

In 1993, one of the biggest stories in recycling came from Washington, D.C. where President Clinton signed an Executive Order mandating the purchase of paper with recycled content. The Order specifies for all federal paper purchasing a minimum of 20 percent postconsumer content by the end of 1994 and 30 percent by the end of 1998.

The federal government uses 300,000 tons of printing and writing paper a year. The increased purchasing of recycled content is significant, but the long-term impact is expected to be greater from state and local procurement programs following the federal lead.

In South Carolina, the Solid Waste Policy and Management Act of 1991, describes a preference in State procurement policies for products with recycled content.

How Paper Recycling Works

At recycling centers, paper is sorted and baled for shipping and is transported to one of more than 600 paper mills in the United States. More than 75 percent of our paper mills recycle some recovered paper, 200 mills depend

on it entirely. The industry is spending billions of dollars to expand recycling capabilities.

According to Cynthia Pollack-Shea, *Realizing Recycling's Potential*, building a mill designed to use waste paper instead of virgin pulp is estimated to be 50 to 80 percent cheaper.

In 1993, the pulp and paper industry continued to build large scale facilities for deinking ledger and newsprint and processing old corrugated. Seventeen new or expanded deinking facilities were completed.

U.S. paper companies are expected to obtain nearly one-third of their fiber from recovered paper by mid-1990s. Add to that the 25 percent from wood wastes and forest residues and the industry will then rely on recovered materials for more than 56 percent of its fiber.

International Paper Recycling Rates

Japan	45%
Spain	40%
Brazil	39%
South Korea	37%
Hungary	37%
West Germany	35%
Sweden	34%

source: A-Way With Waste, Earth Paper Company, 1986

Note: the paper recycling rate in the U.S. was about 40% in 1994.

There are about 1,400 waste paper dealers located throughout the U.S. According to the South Carolina Recycling Markets list, 38 companies in our state handle waste paper from cardboard to computer paper to newspaper to magazines.

Paper recycling is not without its environmental concerns though, as it requires large amounts of water that must be treated to remove chemicals.

However, according to the Institute of Scrap Recycling, there are environmental benefits to paper recycling beyond the obvious benefits of keeping paper out of the waste stream and preserving our forests. Making new products from scrap results in significant energy savings and does use less water than making paper from virgin materials.

Every ton of recycled paper produced requires 7,000 fewer gallons of water to make than virgin paper. Each ton requires approximately 4,100 kilowatthours less energy as well.

According to the Institute, making paper from recycled materials results in 74 percent less air pollution and 35 percent less water pollution.

Waste paper is usually recycled into a lower grade product than the original, as wood fibers break up and deteriorate. Unlike aluminum and glass, a given quantity of wood fiber cannot be recycled perpetually.

One way to keep the quality of recycled paper high is through sorting. High-grade computer printout can be recycled back into computer printout paper, newsprint can become newsprint again. When fibers are mixed they turn out lower grades of paper.

Magazines and slick papers were once thought to be difficult to recycle because of the heavy clay coating used to make the paper hold the inks. Some new techniques suggest that the clay coating helps absorb the toxic inks from the recycling water.

U.S. EPA Recommended Minimum Recycled Content Standards for Paper and Paper Products

Fine Paper	% Waste Paper
•Offset printing	50
•Mimeo and Duplicator paper	50
•Stationery	50
•Office paper	50
•Copier paper	50
•Envelopes	50
•Computer paper	50
•Book paper	50
	% Postconsumer Recovered Material
Newsprint	40
Tissue and Towel	
•Toilet tissue	20
•Paper towels	40
•Paper napkins	30
•Facial tissue	5
Boxes	
•Corrugated boxes	35
•Fiber boxes	35
•Brown paper bags	5
Paperboard	
•Recycled paperboard products including folding cartons	80
•Pad backing	90

In the future more and more magazines may be included in recycling.

Recycled fibers are often made into newsprint and writing paper; roofing felt, insulation board, fiberboard, other construction materials; fruit trays, flower pots, egg cartons and other products made from molded paper pulp; kraft paper, tissue, corrugated cardboard and cardboard boxes.

A large quantity of waste paper is also exported to other countries.

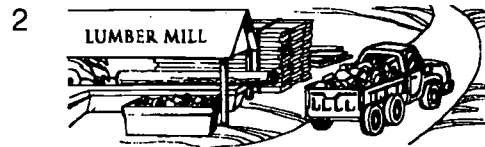
According to the Institute of Scrap Recycling Industries, Inc., leading foreign purchasers of scrap paper include Korea, Mexico, Taiwan, Japan, Canada, Italy, Spain, and Venezuela.

Before Recycling Paper

There are many ways to reduce the amount of paper we use so that we will have less to deal with in the waste stream. In the classroom, always use both sides of the sheet and place scrap paper in a bin for reuse in art projects and as note paper. Many schools use large quantities of

computer paper that can be reused for art and other projects by younger students.

Paper Manufacturing



Wood wastes from lumber mills are used to make paper.



Paper mills turn the wood into paper ready for you to use.

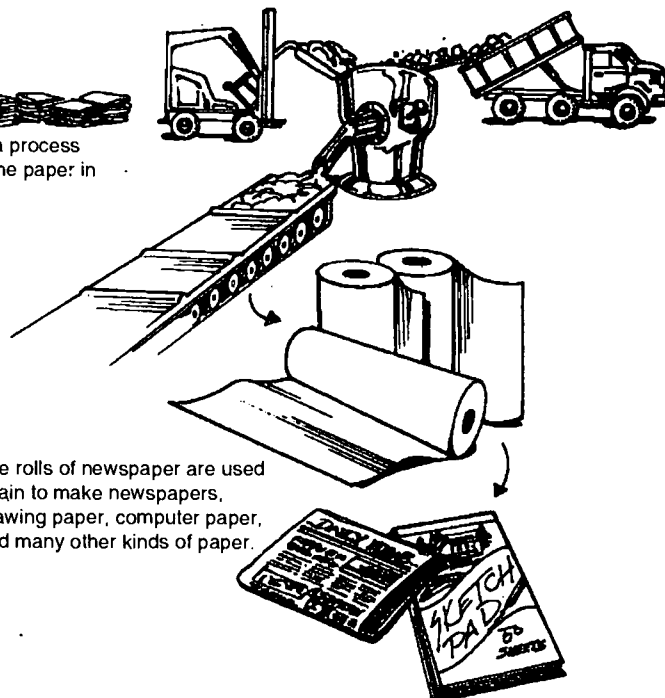


Once paper is used, it should be recycled, not thrown away.



Old paper, like newsprint, must be cleaned in a process called "de-inking" where they wash and rinse the paper in large vats.

Sometimes newsprint and wood wastes are combined, mixed into pulp and poured onto large rollers. Other times, mostly used paper is processed again.



6 The rolls of newspaper are used again to make newspapers, drawing paper, computer paper, and many other kinds of paper.

Paper Manufacturing

To make one ton of paper it takes:

- 3,688 pounds of wood
- 216 pounds of lime
- 360 pounds of salt cake
- 76 pounds of soda ash
- 24,000 gallons of water
- 28 million Btus of energy

In addition, 84 pounds of air pollutants, 36 pounds of water pollutants, and 176 pounds of solid waste are created in the process.

MAKING PAPER

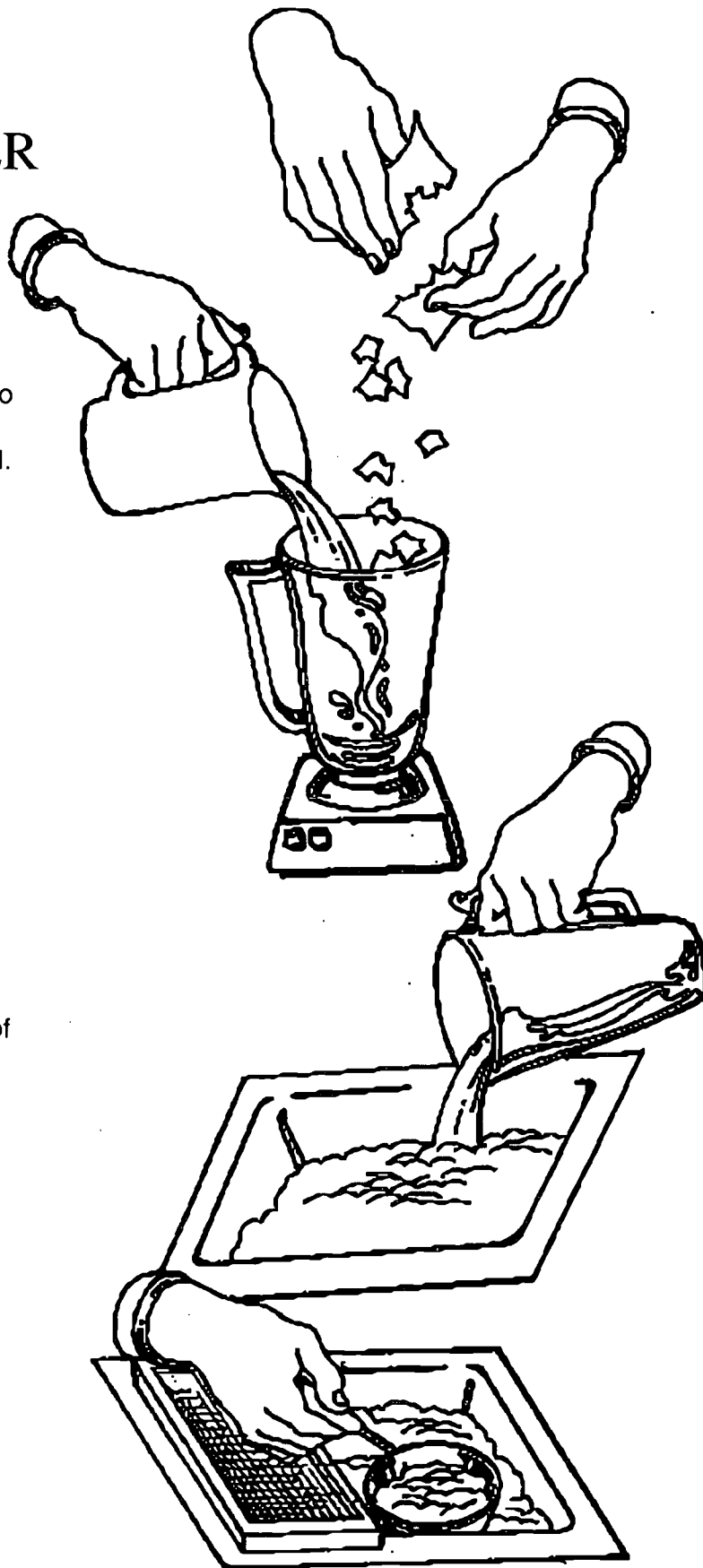
1. Tear sheets of used paper (one different type for each group of students) into small strips about one-inch square. Loosely pack into blender until $\frac{1}{3}$ to $\frac{1}{2}$ full. Add warm water until blender is $\frac{2}{3}$ full.

2. Blend, with lid on, until the paper looks like oatmeal – 5 to 10 seconds.

3. Empty the blender into a pan and add about $\frac{1}{2}$ inch (1.3 cm) of water for every blender of pulp, adding more or less depending upon the thickness of paper desired.

4. Scoop the pulp mixture evenly onto the screen with a cup – hold the frame over half the pan. Let the pulp drain.

OPTION: You may dip the screen under the pulp and pull it up so that the pulp spreads out evenly on the screen. Don't forget to let the excess water drain into the pan.



MAKING PAPER

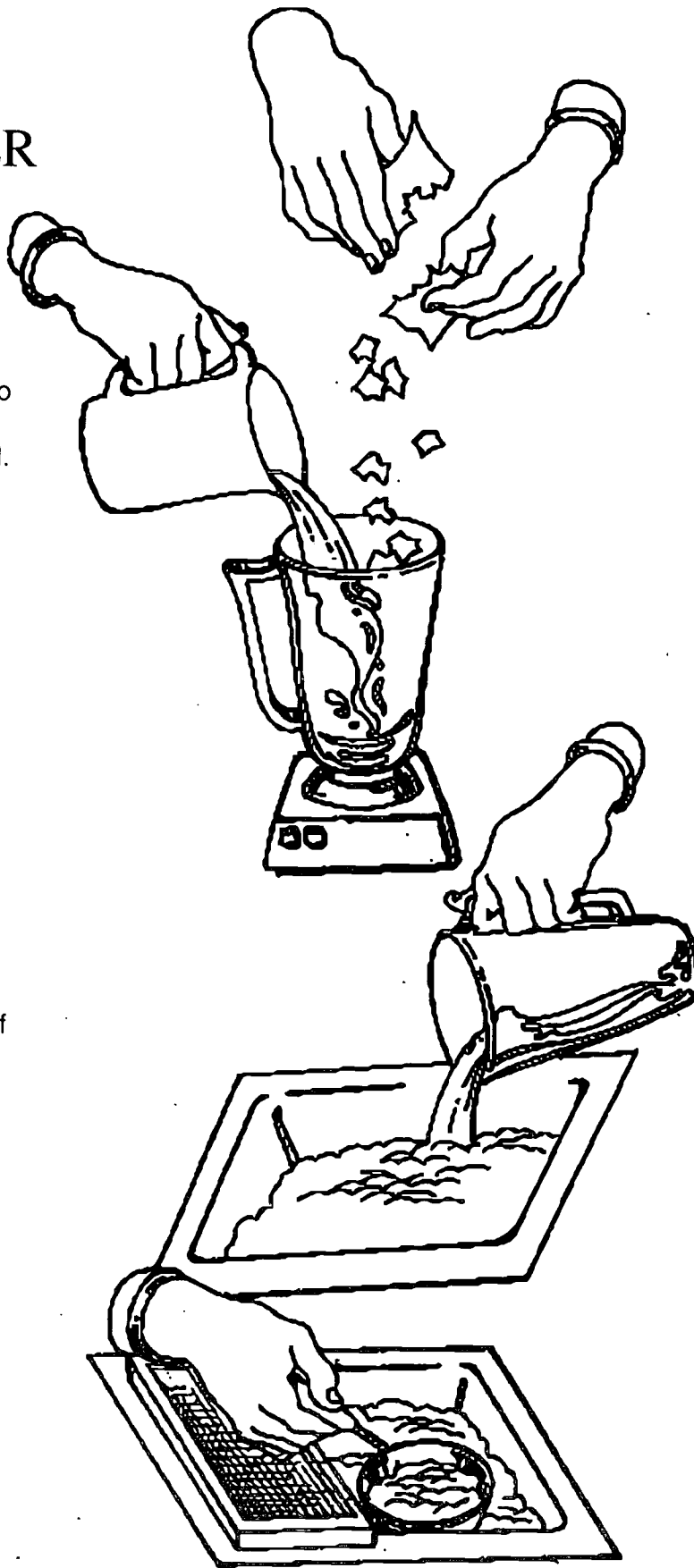
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A Closer Look At Plastic

Today most plastics are made from natural gas and crude oil – valuable nonrenewable resources.

Nationally, plastics make up about 9 percent of our solid waste stream by weight and 20 percent by volume, a share that has steadily increased since plastics were introduced to the consumer market 30 years ago.

In South Carolina, plastics make up about 9 percent, by weight, of our municipal solid waste stream, according to the South Carolina Solid Waste Management Annual Report for 1993.

Today the largest use of plastics is packaging.

Nationally, plastic packaging comprises 25 percent of the plastics produced each year, and is over 50 percent of the plastics found in municipal waste.

Plastics popularity has increased for several reasons: plastic is durable, lightweight, waterproof, adds to consumer convenience, and is relatively inexpensive to produce.

Unfortunately some of the same characteristics that make plastic an attractive packaging material also make it a special waste problem. Though lightweight, plastic is bulky and difficult to compact for burial in landfills. Plastic will not biodegrade in landfills. Even photodegradable plastics will not disappear in today's modern landfill because there is no light.

The Plastic Litter Problem

All litter is unsightly, and whether it's paper or plastic, litter is preventable. Plastic litter has gained special attention though because it is responsible for particular problems in our oceans and on our beaches. Thousands of fish, sea mammals and birds die because they eat and become entangled in discarded fishnets, six-pack rings, plastic bags, and other packaging materials.

During the 1970s and 1980s biologists began paying attention to reports about animals ingesting plastics. As many as 15 percent of the world's 280 species of sea birds are known to have ingested plastic, according to an article in *Natural History*, *Plastics at Sea* by D.H.S. Wehle and Felicia C. Coleman. Sea birds choose a wide variety of plastic objects: raw particles, fragments of processed products, bottle caps, polyethylene bags, and even plastic toys.

Marine turtles consistently select plastic bags to eat thinking that they are jellyfish. Plastic bags have been found in the stomachs of four of the seven species of marine turtles: Leatherbacks from New Jersey, New York, French Guiana, South Africa and the coast of France; Hawksbills on the coast of Costa Rica; Greens in the South China Sea and in Japanese, Australian and Central American coastal waters; and Olive Ridleys off Mexico.

Since this time, international conventions have been passed that help protect our oceans from pollution. These include MARPOL, the Protocol of 1978 to prevent pollution by ships at sea, and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

A Source Reduction Strategy

According to the Society of the Plastics Industry, plastics contribute to source reduction by reducing packaging waste volume. Plastics are lightweight and strong, meaning it often takes less plastic to make certain items compared to other materials. According to a study by Germany's Society for Research into the Packaging Market, if there were no plastics:

- energy used to produce packaging would double
- packaging weight would increase four-fold
- the cost of packaging would double
- the volume of packaging waste would increase by 250 percent.

Plastic & Progress: Less is More

Plastics research has found ways to reduce the volume of plastic used to do certain jobs. This helps conserve resources and reduces the volume of trash that can result. For example, plastic grocery sacks were 2.3 mils (thousandths of an inch) thick in 1976 and were down to 1.75 mils by 1984. In 1989, new technology gave the same strength and durability in a bag only 0.7 mils thick.

Today's milk jug, made of HDPE plastic weighs only 60 grams, the same jug weighed 95 grams – more than 50 percent more – in the early 1970's.

Plastic Snack Bags are Munch Better, or are They?

Snack bags made of plastic have changed significantly in the last decade. Snack bags, such as potato chip bags, now in use are no more than 2/1000 of an inch thick and keep the product fresher longer than the one-third-thicker bags used in the 1980s. However, in making the bags thinner and stronger, engineers have created a mixed plastic package that cannot be recycled at this time.

Today's multi-layer, composite plastic snack bag contains nine layers including a layer of copolymer PP/PE (polypropylene and polyethylene); a layer of polypropylene which acts as a moisture barrier, provides stiffness, and is puncture resistant; and interior layers that include an adhesive modified PP/PE for ink adhesion, inks for high-quality graphics, polyethylene, and aluminum metalization as a oxygen and moisture barrier. The inside layer is a sealant type PP/PE copolymer for sealing, easy opening, and tamper evidence. This construction, although complex, has advantages in materials and filling costs that lower the final product cost to the consumer.

Next time you have the urge to snack, take a look at the bag. It's munch more than it appears.



Why Do We Need Different Kinds of Plastics?

According to information from the Society of the Plastics Industry, all plastics are related, but each resin has attributes that make it best suited to specific

applications. Copper, iron, and aluminum are all metals, but you wouldn't make a car out of iron or a soda can out of copper. In the same way, one kind of plastic would not be suited for all applications. For example, PET is used in soda bottles because it holds in carbonation, polypropylene can be "hot-filled" and HDPE and PVC allow a handle to be put on the container.

How Much Plastic is Recycled?

In 1991, post-consumer plastics recycling (the plastics that you purchase, use, and recycle) increased 44 percent over 1990. However, the U.S. EPA estimates that only 2.2 percent of *all* plastics are being recovered for recycling.

When you break out the figures for plastic packaging recycling the numbers improve. The American Plastics Council reports that 6.5 percent of plastic packaging was recycled in 1992 and that 41 percent of plastic soft drink bottles and 24 percent of plastic milk jugs were recycled in 1993.








Consumer awareness about plastics recycling and a concentration on recycling two popular forms of plastic: PET (primarily from soft drink bottles) and HDPE (from milk jugs, juice and water bottles) has increased plastics recycling in South Carolina as well. These items are recycled throughout the state and are accepted by most collection programs.

Besides more plastic collected through community collection programs, more than 16,000 grocery stores now collect plastic grocery bags for recycling.

IF YOU KNOW THE CODE ... You can tell what resin the product is made from.

To make recycling easier, plastics manufacturers are now using a **standard coding system** on single use plastic containers to identify the **resin** type (the artificial substance similar to natural resin from trees.) Since plastic recycling opportunities are different throughout the country, consumers should find out which types of plastics are recycled in their communities and make purchases and recycle accordingly. The plastic type used for many typical products is changing as more manufacturers move to packaging using Number 1, PET and Number 2 HDPE. These two plastic types are the most recycled in South Carolina.

Plastic Container Code System For Plastic Containers

<u>Symbol/Code</u>	<u>Material</u>	<u>Typical Products</u>	<u>Can Be Recycled Into</u>
 1	PET or PETE Polyethylene terephthalate (PET or PETE)	soft drink bottles, peanut butter jars. 25% of all plastic bottles.	carpets, surfboards, sailboat hulls, strapping
 2	HDPE High-density polyethylene	milk, water & juice jugs, detergent bottles. More than 50% of all bottles.	trash cans, base caps for soda bottles, detergent bottles, drain pipes
 3	V Vinyl/polyvinyl chloride (PVC)	cooking oil bottles, some shampoo bottles. Less than 6% of bottles.	fencing, handrails, house siding
 4	LDPE Low-density polyethylene	dry cleaning, bread & trash bags, squeeze bottles. 10% of bottles.	grocery bags, garbage can liners
 5	PP Polypropylene	yogurt cups, margarine tubs, straws. 5% to 10% of bottles.	birdfeeders, pails, water-meter boxes, car-battery cases
 6	PS Polystyrene	egg cartons, meat trays, coffee cups, carryout containers, video tapes.	pencil holders, tape dispensers, license-plate frames, trays
 7	Other All other resins and layered multi-material	microwavable serving ware.	benches, picnic tables, roadside posts, marine pilings

There are hundreds of different kinds of plastics, more than 46 of which are in common use. Each type has a different chemical composition and is carefully engineered for a specific purpose. Layers of different plastics can be used in just one container, each adding a special quality to the design. The **National Voluntary Plastic Container Coding System** identifies plastics for recycling using a recycling symbol with the plastics coding number in the center. Note: this symbol does not mean that the plastic can be recycled in your area, it simply refers to the resins type of the plastic. In South Carolina, plastics coding is mandatory.

What Happens to Plastic Collected for Recycling?

Plastics from community collection programs are sorted by their code (many programs only accept PET and HDPE, or plastic soda bottles and milk jugs) and are then taken to reclamation centers where sorted plastics are chopped, washed and converted into flakes or pellets. These flakes or pellets are then used to manufacture a new product.

Originally, recycled plastic was limited to making park benches and landscaping timbers. These items are still made today from recycled mixed plastics, but today's more sophisticated plastics sorting and recycling makes a variety of products.

- **Recycled PET** is used in making soft drink bottles, deli and bakery trays, carpets, fiberfill, tennis ball containers and paint brush bristles.
- **Recycled HDPE** can become bottles for laundry products, recycling bins, agricultural pipe, bags, soft drink bottle base cups or motor oil bottles.
- **Recycled vinyl** becomes pipe, fencing and non-food bottles.
- **Recycled LDPE** is used to manufacture new bags and films.
- **Recycled PP** is used in auto parts, carpets and industrial fibers.
- **Recycled PS** is used in a wide range of products including office accessories, cafeteria trays, toys, video cassettes and insulation board.

Proper Sorting is Key to Plastics Recycling

The plastics coding system is critical to recycling because several types of plastic can look the same. For example, a bottle made from clear, number 3 polyvinyl chloride (PVC) may look identical to bottles made from clear, number 1 polyethylene terephthalate (PET), or like packages made from

clear, number 6 polystyrene (PS). A recent study shows that even small amounts of the wrong type of plastic can contaminate and ruin an entire load of recycled plastic. If even one number 6, PVC, bottle slips through a sorting system into a container of 1,000 pounds of PET plastic flaked for processing, the entire load can be ruined.

This is why many communities choose to recycle only certain containers such as milk jugs (number 2 HDPE) and soda bottles (number 1 PET). This avoids any misidentification.

PET: A Recycling Success Story

The PET plastic bottle was patented in 1973 and in 1978 the first PET soft drink container appeared on the market.

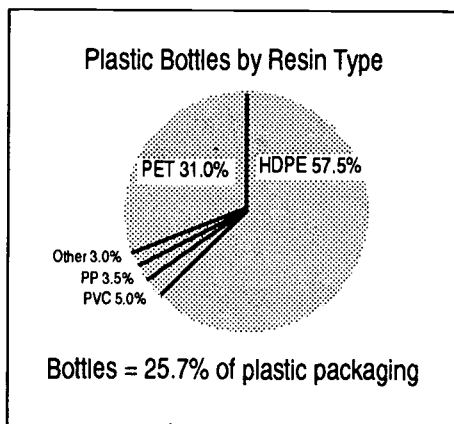
Today, PET plastic is identified with the coding "1" and PETE. In 1991, programs to recycle PET plastic containers increased dramatically.

According to the National Association for Plastic Container Recovery (NAPCOR), among curbside and drop-off programs, 89 percent collect PET plastic.

Today PET plastic is second only to aluminum in recycling market value.

Plans to use recycled PET plastic in new soft drink bottles were introduced by the Coca-Cola Company and PepsiCo

Inc. in 1991. Closed-loop or bottle -to-bottle recycling is expected to have a major impact on market growth. The new recycling processes are called glycolysis and methanolysis. Post-consumer plastics are literally broken down to their building blocks and repolymerized, or rebuilt, ensuring the purity of the recycled resin.



From Soda Bottles to Apparel

One of the largest recyclers of plastics in the United States is Wellman, Inc., located in Johnsonville, South Carolina. Wellman uses recycled plastic to create fibers used in a variety of products, such as carpeting and filling for pillows and clothes. Hoechst Celanese in Spartanburg is opening a \$6 million recycling plant to process plastics. Company representatives estimate that about 150 million PET and HDPE bottles and containers will be processed annually.

Wellman recently announced a process that allows them to refine and purify plastic bottles, creating a new fiber, a recycled polyester – Fortrel EcoSpun, the Renewable Resource™ that is suitable for making apparel. According to Scientific Certification Systems, an independent company that evaluates environmental claims, Wellman has earned the right to display the Scientific Certification Systems green cross certification for the product.

The environmental merits of the fiber include:

- For every pound of 100 percent Fortrel EcoSpun, approximately ten bottles are kept out of landfills.
- 4.8 billion bottles were kept out of the landfills in just two years of recycling by Wellman, saving 1.3 million barrels of oil.

Johnson Controls Launches New Technology

In 1994, Johnson Controls, Inc., the largest manufacturer of soft drink bottles in North America, announced a new process that allows old plastic soft drink bottles to be turned into new ones. U.S. Food and Drug Administration (FDA) cleared the way for Johnson Controls' Supercycle™ 100 percent post-consumer recycled PET material to be used in all types of beverage and food containers. The process incorporates high-intensity washing, high temperature (500 degrees F) and other advanced cleaning procedures to meet strict FDA standards. The process is reported to be less expensive than depolymerization or multi-layer processes.

How Plastic is Made

Plastics are made by linking together small single chemical units called monomers in repetition to build one large molecule called a polymer. The plastic monomers are made from hydrogen and carbon elements "hydrocarbons," derived from petroleum and natural gas, in combination with small amounts of oxygen, nitrogen and other organic compounds. When rearranged chemically, they produce a solid resin. The resins are used to make hundreds of different plastics, all of which fall into three basic categories.

Thermoset plastics, which can be heated and molded only once, are used in automobile bodies, toys, computer casings and to make nonstick cookware. Thermoset plastics are difficult to recycle.

Thermoplastics, the kind of plastic used in milk jugs, are recyclable. They may be remolded several times. Thermoplastics are widely used in packaging. Some reuses for thermoplastics are boat docks, park benches, pallets and filler for ski jackets.

The newest type of plastics are degradables. Some degradables can be broken down by light, others by salt water and others by biodegradation. Degradable plastics are not recyclable and have yet to prove themselves as a major solution to the plastic waste stream. Because there is little light or air inside landfills, degradable plastics do not breakdown in landfills.



RESOURCE SECTION 35

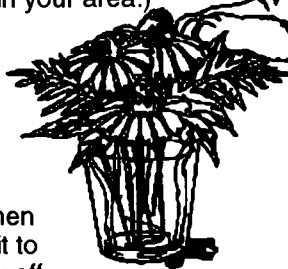
The Nine Lives of a Peanut Butter Jar

The life of a peanut butter jar begins when you buy it filled with your favorite brand. When emptied and cleaned, your family can use it in many ways.

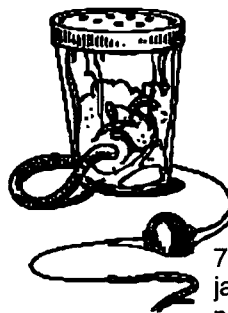
1. Enjoy your favorite peanut butter. When the jar is empty, rinse it out and let the jar move on to lead several more useful lives.



9. If you collect too many peanut butter jars, be sure to recycle the extras (if this type of plastic is recyclable in your area.)



8. Then use it to show off flowers for your table.

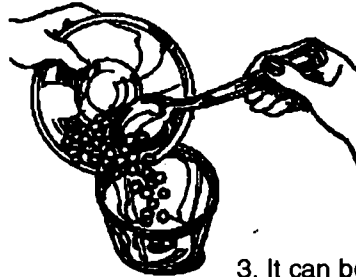


7. Take the jar on your next fishing trip to carry live bait.

2. It's a perfect container for collecting marbles.



3. It can be used to store leftovers.



4. And to mix a batch of concentrated juice.



5. It can be used to store foods bought in bulk such as maple syrup.



6. The jar makes a great cookie or biscuit cutter.



A Closer Look At Metals

Industry has recycled metals for many years. Although some consumers may think of metals recycling as new, the first two major aluminum recycling plants opened in Chicago and Cleveland in 1904. Because of the expense of mining, business has used recycling of metals as a way to keep costs down.

Today, consumers are eager to recycle metals for several reasons: to prevent depletion of valuable resources, to prevent the pollution that mining new metals can cause, to reduce the amount of garbage they throw away, and to make money.

Recycling Aluminum

Several characteristics make aluminum a valuable resource. Lightweight, versatile and strong while flexible, aluminum is used for packaging, building, automobile and aircraft construction.

To make aluminum more rigid, it can be alloyed with small amounts of other metals. Because of its love for oxygen, aluminum resists corrosion by forming a protective coating of aluminum oxide when exposed to air. It is a good conductor and insulator.

Aluminum makes up about 8 percent of the Earth's crust, and it is the third most common element after oxygen and silicon. Aluminum was discovered in the 1820s. At that time it was worth \$1,200 a kilogram, more than gold.

Widely dispersed through most clays and rocks, it's commonly found as hydrated aluminum oxide. It is never found naturally in its metallic state. The greatest concentrations of aluminum are found in bauxite ore, where it is found as alumina in combination with oxide, titania, and silica.

Most of the world's bauxite reserves are located in the subtropics. Substantial bauxite deposits are located in Jamaica, Australia, Surinam, countries of the former Soviet Union, Guinea, France,



The Recipe for One Ton of Aluminum

These resources are used to produce one ton of aluminum:

- 8,766 pounds of bauxite
- 1,020 pounds of petroleum coke
- 966 pounds of soda ash
- 327 pounds of pitch
- 238 pounds of lime
- 197 million Btus of energy.

The wastes created include:

- 3,290 pounds of red mud (iron, titanium and silica)
- 2,900 pounds of carbon dioxide
- 81 pounds of air pollutants
- 789 pounds of solid wastes.

Recycling saves 95 percent of the energy required to produce aluminum from raw materials.

Yugoslavia, Greece, and Hungary. The limited United States reserves are located in Arkansas, Georgia and Alabama.

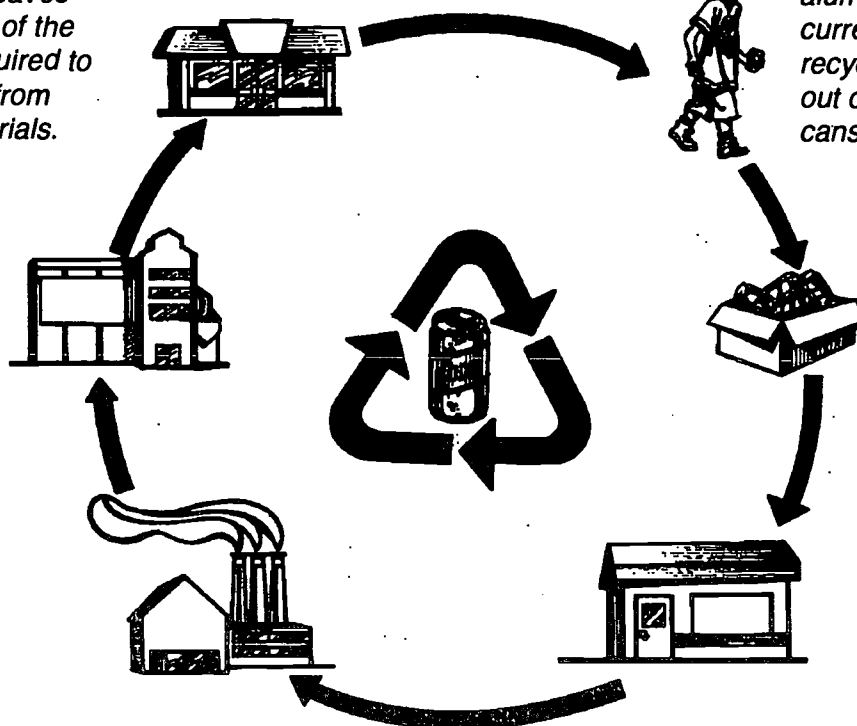
The U.S. imports 90 percent of its bauxite.

Aluminum in Transportation

The amount of aluminum used in cars made in the United States increased from 78 pounds per car in 1972 to more than 200 pounds per car today. This is because aluminum construction helps make cars that are lighter and use less gas.

As many as 90 percent of the truck trailers used in this country also have aluminum bodies. Aluminum is the primary aircraft material, making up about 80 percent of the structural weight of jets.

Recycling Aluminum saves 95 percent of the energy required to produce it from virgin materials.



About 68 percent of aluminum cans are currently being recycled – that's four out of every six cans!

From Ore to Useful Metal

Surface mining of bauxite produces solid waste, air pollution and hazardous waste. Once taken out of the ground it requires further refinement. The metal is then poured into bars and transferred to manufacturing plants which re-melt and form the aluminum into various items.

Fifty-five percent of the world's aluminum is produced in the United States, the former Soviet Union, Canada, Japan and West Germany.

While the supply of aluminum resources is plentiful, mining, refining and manufacturing products from aluminum uses energy and creates waste and pollution. This is why aluminum should never be thrown away.

The first aluminum beverage can appeared in 1963 and the first consumer can recycling center was opened in 1968.

Why Recycle Aluminum?

Recycling a single aluminum can saves as much energy as a can half-filled with gasoline. In addition, recycling aluminum eliminates 95 percent of the air pollution.

All aluminum products, including aluminum foil, cans and foil containers can be recycled.

According to the Alcoa Aluminum Company, the turn around time for an aluminum can is only six weeks from manufacturing the can, to filling it, delivering it to the store, being purchased, emptied, recycled by the consumer, shipped to a processing plant, made into a sheet of aluminum, made into an aluminum can, shipped to the filler, filled, and shipped to the store.

When we recycle aluminum, it goes to scrap dealers that sell it to smelters. The smelters chemically analyze the aluminum and shred and decontaminate it. Steel is removed from shredded

aluminum as it passes over magnetized conveyor belts. Contamination of more than 1 percent non-aluminum metals makes the aluminum unusable in a smelter.

Once shredded and decontaminated, the aluminum scrap is melted for 18 hours. The molten metal is then poured into forms and allowed to cool. The resulting ingots are transported to manufacturing plants, re-melted and formed into new products.

Facts About Aluminum ...

Today, enough aluminum cans are recycled to rebuild the entire U.S. commercial airline fleet every 10 weeks.

Each person in the United States uses an average of two pounds of aluminum foil every year.

Aluminum is one of the most durable packaging materials available. That's why it should always be recycled. If you throw an aluminum can out of your car window today, it will still litter the earth hundreds of years later.

One of the most innovative strategies in aluminum recycling is the reverse vending machine. These machines found in several areas of the state, take your cans and give you money!

Aluminum recycling is profitable for everyone. Companies recycling aluminum make as much as \$2 million every day! Many communities use the profits from aluminum recycling to fund other recycling projects.

Other Metals

According to the Steel Can Recycling Institute, steel is the most recycled material in the United States with a 66 percent recycling rate. This high recycling rate is due to a combination of industrial and consumer recycling. Consumers recycle about 41 percent of the steel cans they use. Today, over three-fifths of all steel products contain an average of 25 percent recycled steel; almost two-fifths contains 100 percent recycled steel.

When we recycle "tinned" food cans, we are really recycling steel cans with a very thin coating of tin. Tin protects the steel from corroding or rusting.

Bimetal cans are tin cans with an aluminum top. These cans are not easily recycled because they contain three metals which must be separated for recycling.

You can tell the difference between tin (steel) and aluminum cans with a magnet. Magnets will attract steel but not aluminum. Bimetal cans also attract magnets. Magnetic separation makes steel easy to remove from other wastes.

Steel cans collected for recycling are detinned. The tin is reused and the steel taken to steel mills.

Every ton of steel recycled saves 2,500 pounds of iron ore, 1,000 pounds of coal, and 40 pounds of limestone that would be used in making steel from virgin materials.

The steel industry has also looked at source reduction as a way to reduce waste. Today, improvements in steelmaking quality and manufacturing methods have resulted in a net reduction in the amount of steel in many steel products. Steel cans, for example, contain an average of one-third less steel than the cans produced in 1975.

A Closer Look at Used Oil

Putting Used Oil In Its Place

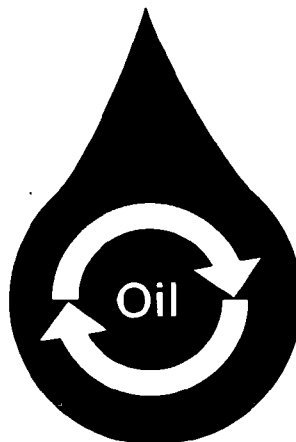
Oil is the primary energy resource in developed countries. It powers our cars, heats our homes, and runs our factories. Oil is a nonrenewable resource, that is, a resource of limited quantity. Currently more than half of every barrel of oil used in America becomes vehicle fuel; and 13 percent goes to non-energy uses including plastics, petrochemicals, lubricants, asphalt, and coke.

Geologists report that it could be just 20 to 40 years before the easy-to-pump petroleum is spent, and we must turn to oil shale and offshore wells.

According to Norm Hinman, manager of the Alternative Fuels Program of the U.S. Department of Energy's Solar Energy Research Institute, "When we project out to the year 2030, it looks like we'll be importing about 80 percent of our oil."

With the future oil supply in question, it is surprising to find out that millions of gallons of used but useful oil are being poured on the ground and down the drain every year.

Mismanagement of used motor oil is a serious problem. Every year, privately owned cars and light trucks generate more than 800 million gallons of used crankcase oil nationally.



When changed at a service station or quick-lube shop, the oil will enter a managed system where it will be sent for re-refining or reprocessing. But not all used motor oil takes this route.

According to the U.S. EPA, each year people who change their own oil – do-it-yourselfers – produce more than 210 million gallons of used motor oil, and only about 32 percent of this used oil is properly collected and recycled. The

remaining portion, about 143 million gallons of used motor oil, ends up contaminating the environment. That's the equivalent of 14 Exxon Valdez spills per year.

How do 143 million gallons of used oil get from our cars into the environment? Well, studies show that this used oil comes from millions of well-intentioned do-it-yourselfers who change their own motor oil and then dispose of it improperly.

The South Carolina Department of Health and Environmental Control's Office of Solid Waste Reduction and Recycling estimates that nearly 1 million gallons of used motor oil are improperly disposed of each year in South Carolina. The S.C. Solid Waste Policy and Management Act of 1991 bans the disposal of used motor oil in municipal and county landfills after May 27, 1992. With these new regulations in effect, there are only two alternatives: either take motor oil to a used oil collection center for recycling, or break the law and dump it illegally into the environment.

RESOURCE SECTION 41

While oil tanker accidents make the news, the United States Coast Guard estimates that sewage treatment plants discharge twice as much oil into coastal waters as do tanker accidents. A major source of this pollution is the one-pan-at-a-time dumping of used motor oil. A 1981 survey by the United States Department of Energy found that 68 percent of all do-it-yourself oil changers improperly dispose their used motor oil by burning it, dumping it, or finding other uses.

Used motor oil should never be emptied into sewers or storm drains, or dumped directly onto the ground to kill weeds or to suppress dust on dirt roads. Also used oil should never be thrown into the trash where it will end up in landfills.

A Little Goes A Long Way...

Unfortunately, even *a little* used oil can go a long way in polluting soil, streams, and lakes. Oil in any form can have an effect on our environment. Studies have shown that after a spill, it may take up to 20 years for the environment to recover to its original condition.

One gallon of used oil can potentially destroy 1 million gallons of fresh water – enough to supply 50 people with drinking water for a year.

One pint of oil can produce a slick on water about one acre in size and will kill floating aquatic organisms.

You can taste less than 300 parts per million of oil in fish and smell and taste only 5 parts per million of oil in water.

Why Collect Used Oil?

Recycling used oil makes good sense. Recycling motor oil not only eliminates a health hazard and protects the environment, it also saves energy.

All automotive oils can be recycled safely and productively. Used oil can be recycled and used again as a fuel, lubricant, or other petroleum products.

The durable qualities that make motor oil a fine lubricant also make it ideal for recycling. Motor oil never wears out. It just gets dirty. Through the process of re-refining, impurities are removed by heating and filtering, yielding “new” oil.

One gallon of used oil can make 2 1/2 quarts of lubricating oil, while it takes 42 gallons of crude oil to produce the same amount.

According to studies by the National Bureau of Standards, the Army, and the Department of Energy, re-refined oils perform as well as virgin oils. However, you should check your car’s manual to see if re-refined oil is recommended.

Oil is a valuable resource that should never be thrown away.

Recycling Used Oil

Used motor oil can also be recycled and used again as fuel. In power plants, used oil can be used as a fuel source to produce electricity.

Used oil has nearly 1 1/2 times the energy-producing value of coal. One gallon of used motor oil can be used to generate 18 kilowatthours of electricity.

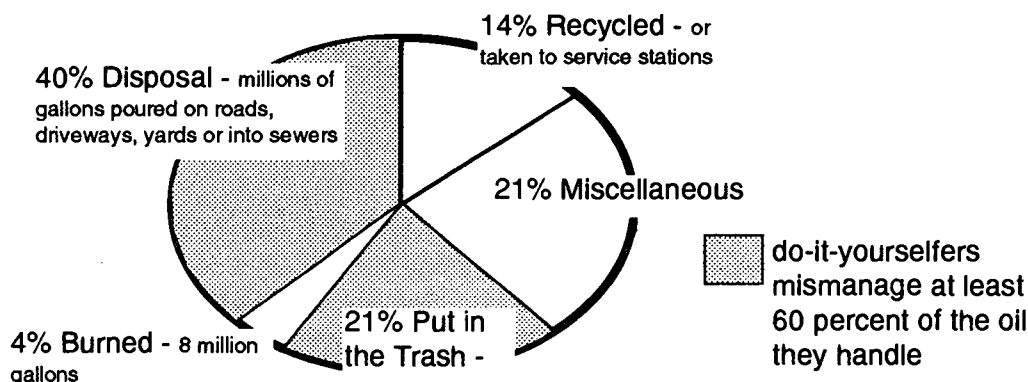
Recycling used oil makes good sense. Recycling motor oil not only eliminates a health hazard and protects the environment, it also saves energy.



RESOURCE SECTION 42

What Happens to Do-It-Yourself Oil Nationally

source: Analysis of Potential Used Oil
Recovery from Individuals, Market
Facts, Inc. 1991



Two gallons of used oil will provide the electricity to run the average household for about 24 hours, or

- cook 48 meals in the microwave
- blow dry your hair 216 times
- watch TV for 180 hours (7 1/2 days).

It's More than Just Oil

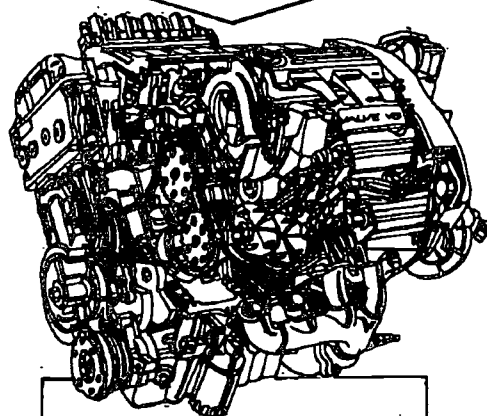
It's not just the damaging effects of the used oil that poses a threat to the environment. Used motor oil contains many additives and contaminants.

As much as 20 percent of automotive oil is composed of substances that are added to improve performance, such as to inhibit rust or prevent foaming. Oil will also pick up sediment and gasoline components and additives from the engine during combustion. Lead, as well as benzene, cadmium, zinc, and magnesium are all added to used oil and may contaminate the environment if not properly handled.

While used motor oil (the kind that comes from your automobile) has not been classified as hazardous waste by the U.S. EPA, many of the contaminants that used oil contains are considered toxic. Laws do regulate large quantities of used oil and used oil that contains high levels of hazardous substances.

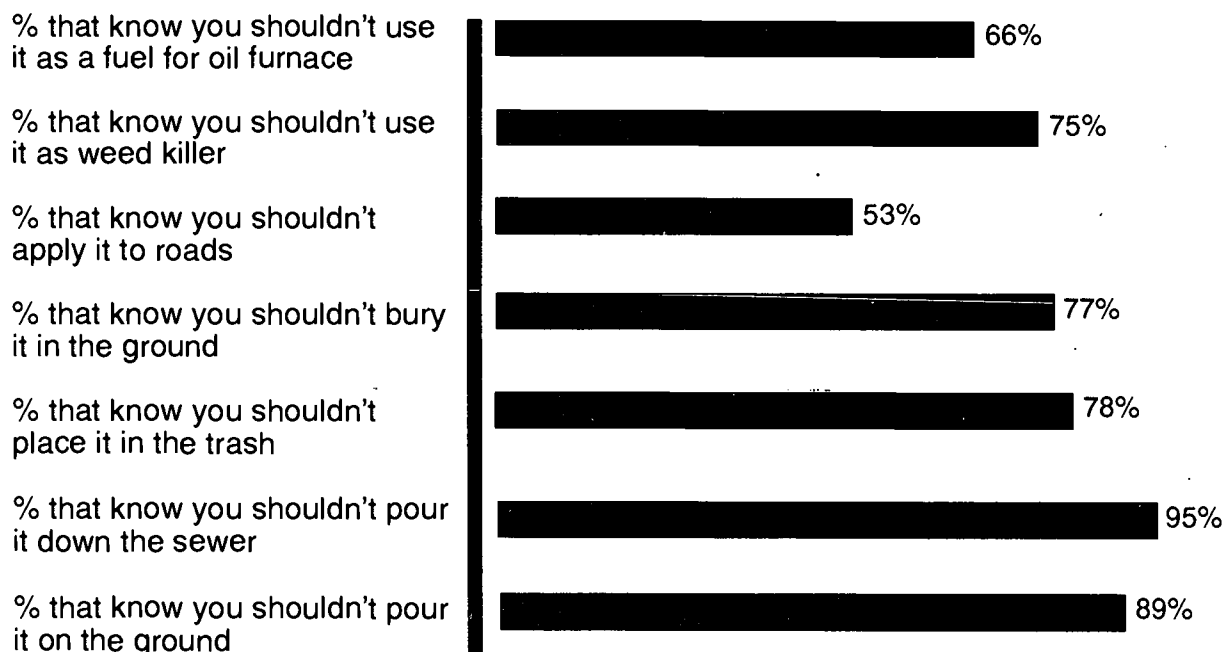
Your Engine's Oil: Coming & Going

New motor oil contains:
pour point depressant;
detergent; foam, oxidation,
rust, and corrosion inhibitors;
viscosity index improvers;
anti-wear additives



Used motor oil contains:
all the original ingredients
PLUS water and dirt;
iron and steel particulates;
copper; heavy metals
including lead, cadmium,
zinc, and barium; sulfur;
ash

Public Perceptions of the Harmfulness of Various Used Oil Practices



As this survey shows, most consumers recognize the damage that can be done by used oil, yet only about 30 percent of those changing their own oil have been recycling it.

Getting People Involved in Used Oil Recycling

According to the U.S. EPA's brochure, "How to Set Up a Local Program to Recycle Used Oil," if all used oil improperly disposed of by do-it-yourselfers were recycled, it could produce enough energy to power 360,000 homes each year or could provide 96 million quarts of high quality motor oil.

So, why doesn't everyone recycle their used motor oil? The U.S. EPA also reports that publicity about used oil recycling can triple do-it-yourselfer participation in local oil recycling programs. This is why many states, including South Carolina, have passed laws making improper disposal of used oil illegal and have sponsored aggressive advertising campaigns to promote used oil recycling.

How To Get Started

Do-it-yourself oil changers can collect their used oil by following these simple procedures:

- drain oil and pour into a clean, sturdy container with a tight-fitting, screw-on top
- never mix used motor oil with anything, such as antifreeze, gasoline, paint thinner, carburetor cleaner, solvents, or water
- use containers smaller than five gallons
- avoid plastic bottles once used for bleach, cleaners, and automobile fluids.

Used motor oil filters contain about one cup of oil that should be recycled. To recycle your oil filter:

- puncture the filter with a screwdriver
- drain the oil into your collection container.

Many service stations and quick lube shops will take used oil filters for recycling. These companies are required to recycle the used filters they collect.

South Carolina's Used Oil Success Story

In South Carolina, it is against the law to dump used oil into the environment or put it in the trash. The South Carolina Solid Waste Policy and Management Act of 1991 prohibits the disposal of used oil in county and municipal landfills. The Pollution Control Act also makes dumping used oil on the ground or in waterways illegal, with fines up to \$200 and \$10,000 respectively.

So, what can South Carolina's do-it-yourselfers do with their used oil? *Recycle It!*

**For more information on
used oil recycling and locations to
recycle used oil in
South Carolina,
call 1 (800) 768-7348, or
1 (800) SO USE IT.**

Used Oil Recycling Begins In S.C.

In 1990, as a part of local Earth Day activities in Moncks Corner and Myrtle Beach, Santee Cooper, the state-owned electric utility, collected more than 600 gallons of used motor oil in a single day. This demonstrated South Carolina's willingness to participate in used oil recycling.

Santee Cooper expanded its test with more collection sites in a program called GOFER (Give Oil For Energy Recovery). From eight sites, more than 4,000 gallons of used motor oil were collected in just six months.

The S.C. Used Oil Partnership

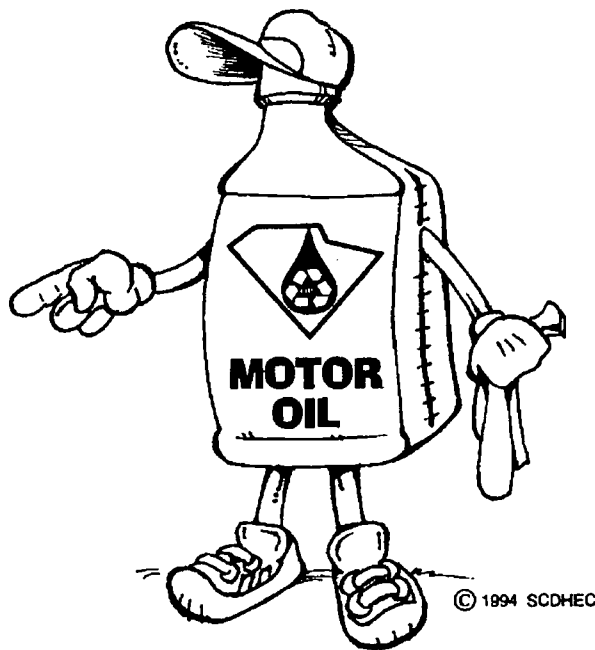
With the encouragement of these test results, the S.C. Used Oil Partnership was formed to promote public awareness of the importance of proper disposal of used motor oil. In addition to Santee Cooper, this public-private partnership consists of

the S.C. Department of Health and Environmental Control, the S.C. Department of Transportation, and the S.C. Petroleum Council.

The statewide used oil recycling awareness campaign features NASCAR driver Jeff Gordon as the spokesperson for used oil recycling.

In 1992, the program's first full year, almost 300 collection sites brought in more than 250,000 gallons of used oil from do-it-yourselfers.

This represented a 25 percent recovery of the estimated 1 million gallons of used oil that are improperly disposed of each year in this state. In 1995, more than 600,000 gallons were collected. Most of this used oil is recovered as fuel and is burned in Santee Cooper's generating stations in Georgetown (the Winyah Station) and in Moncks Corner (the Jefferies Station.) These plants typically use coal as an energy source and are specially equipped to burn used oil as fuel.



To recycle oil, just take it to one of the many used oil collection sites around the state such as Santee Cooper's GOFER (Give Oil For Energy Recovery) program. Many service stations also take used oil.

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Today, the program collects more than 1,000 gallons of used motor oil a day. Collection sites statewide have collected more than 600,000 gallons of used motor oil. With more sites being added, used oil recycling in South Carolina is a success story that demonstrates that South Carolinians are eager to protect our environment.

From You to the Environment

If you pour used motor oil in a storm drain or ditch, or anywhere in your backyard, there's a good chance that the oil will end up in a nearby stream, river, or lake. The storm drain is the metal or concrete opening at the sides or curbs of streets. They are also called catch basins. When it rains, the first drops of water soak into the ground, but the excess or runoff goes into these storm drains.

From the storm drain, this runoff enters pipes that carry it to larger pipes buried under the ground. These pipes empty the water into the nearest drywell or waterway. This can be a creek, river, or lake. So if you pour used motor oil on the ground or down the storm drain, it may end up on the feathers of ducks or the gills of fish in a nearby lake.

In some areas, the storm drain joins sanitary sewer pipes and the runoff goes to a sewage treatment plant. The amount of treatment varies from community to community and it is expensive.

In areas where there are no storm drains and used motor oil is dumped into the ground, it runs with rain water to the nearest ditch or gully and on to the nearest waterway. Oil dumped on the ground may also seep down with rain into the groundwater.

Water drains or soaks into the ground until it hits a layer that it can not soak through, an impermeable layer. The water then collects in the spaces between sand, gravel, or rock. Underground areas where groundwater collects are called aquifers. Some aquifers replenish lakes or streams. Others are enclosed by layers of rock and do not move. Wells are drilled into both kinds of aquifers. Aquifers around the country are becoming contaminated at an alarming rate by used motor oil and other harmful substances that are disposed of improperly.

While the motion of water and the natural purification properties of sand and clay do work to filter many impurities out of water, this natural cleansing can not keep pace with the pollution that is flowing into our water systems.

When you pour used oil down the drain, it goes to the municipal sewage treatment system or into a septic tank. These systems are not designed to deal with used oil or the contaminants that used motor oil contains.

While the problems caused by disposing of used oil by pouring it out may seem obvious, many of these same water contamination problems can occur when used motor oil is thrown into the trash.

With the passage of the South Carolina Solid Waste Policy and Management Act of 1991, used oil is banned from disposal in our landfills. This means that used oil should never be put into your trash.

Used motor oil, disposed in landfills built before today's strict, federal Subtitle D regulations, can also find its way down through the soil to our groundwater.

With the passage of the South Carolina Solid Waste Policy and Management Act of 1991, used oil is banned from disposal in our landfills. This means that used oil should never be put into your trash.

Used Oil and the Environment

In addition to ground water pollution, a film of oil on the surface of the water can block photosynthesis and slow the production of oxygen. The reduced oxygen supply then causes stress to the point of death in aquatic organisms. Large organisms such as mammals and birds are the most familiar victims of oil pollution because of their visibility and emotional struggle to combat oil in the environment. Feathers and fur stick together, become matted and lose their ability to insulate the animal against cold. Death may result from temperature shock or from the eating of oil as it is cleaned from their coats.

Oil can also clog breathing structures or be absorbed into tissue and passed along the food chain, even to humans who eat fish or shellfish. Microscopically, oil may harm bacteria or plankton, the basis of the food chain.

According to *Global Ecology* by Colin Tudge, Oxford University Press, 1991, oil entering our environment does devastating harm:

"It [an oil spill] is oblitative; it renders huge areas of habitat inaccessible. Thus it reduces all populations with which it comes into contact, and would certainly render some of them locally extinct.

"The effect is made worse because individual marine species tend to piece their habitats together from various components: plankton, inter-tidal zone, and so on. Damage to any one component will affect parts of the system elsewhere. Then again, all the creatures are inevitably locked into a food web. If one is affected, then all the others are affected as well."

More Facts About Used Oil

- The total generation of used oil increased by 2 percent between 1988 and 1991, from 1.35 billion gallons to about 1.38 billion gallons. Total generation numbers include the oil used by private automobiles, trucks and other transportation as well as commercial and industrial sources.
- The growing interest in recycling used oil is keeping more used oil out of landfills. Reflecting the increased interest in recycling, the proportion of used oil disposed in landfills, incinerated, and dumped on the ground and down sewers dropped from 33 percent in 1988 to 28 percent in 1991.
- Currently, 11 major oil companies have formal programs in place to support and encourage service station owners to accept used oil from do-it-yourselfers. More than 1,000 communities across the country have initiated drop-off and curbside programs to collect oil from do-it-yourselfers.
- In 1983 it was estimated that as much as 68 million gallons of used oil were spread on gravel and dirt roads as a dust suppressant, commonly referred to as road oiling. By 1988 less than 34 million gallons were used for this purpose. Today, 30 states prohibit the practice of road oiling with used oil, and 14 states regulate the practice.
- Because the practice of illegal dumping of used oil is seldom directly observed, estimates of the amount of used oil dumped on the ground are based on the amount of used oil generated which can not otherwise be accounted for.

source: Perspectives on the Generation and Management of Used Oil in the U.S. in 1991

Excerpts from

"THE WASTE OIL MONSTER"

by John Grassy
Garbage magazine, 1991

More than 780 million gallons of motor oil go in and out of American cars each year. When changed at a service station or quick-lube shop, the oil will enter a managed system, where it will be trucked off for re-refining or reprocessing. But only about half of the motor oil used annually takes this route. The other 367 million gallons keep environmentalists awake at night. This is DIY oil (Do-It-Yourselfer), the oil of the backyard mechanic who prefers to save some money and do the job at home.

A 1981 survey by the U.S. Department of Energy found that 61 percent of all DIYs improperly dispose their used oil, burning it, dumping it, or finding creative reuses.

Oil poured on the ground doesn't evaporate — it sinks in. Poured down storm sewers, it begrimes pipe walls, gums up screens in the treatment plant, or may even bypass treatment and go straight into a waterway. The Coast Guard estimates that more oil dribbles from the land into coastal waters each year than is spilled in tanker accidents. All this oil re-enters the environment with a toxic load significantly higher than that of virgin crude. Used oil has traces of the lead,

arsenic, cadmium, chromium, barium, and zinc that accumulate in the engine. By land or by water, oil oozes into groundwater supplies and the food chain.

Just one pint of oil can make a one-acre slick on a lake or stream, and the resulting film impedes the replenishment of dissolved oxygen by blocking out sunlight needed for photosynthesis. One quart of 10w-40 will foul the taste of 250,000 gallons of H₂O. And for oil to disappear, it must be eaten by microorganisms. These tiny creatures need oxygen, too, and as they multiply to consume the oil, they can deplete the oxygen available to fish and other aquatic life.

Let no one say ours is not an oil-rich nation. We deposit more than 200 million gallons of it in our soil and waterways every year, not counting what's drained from the likes of lawn mowers, weed whips, and boats. With so much oil running loose every year, how can it be we've heard so little about the problem?

Julie Stoneman, for five years the director of Michigan's long-running used-oil recycling program, says it's too easy to dump oil and get away with it. "Oil is a liquid," she says. "You can't see a mountain of oil, like you can plastic or paper. It's dumped in small quantities over wide geographic areas. You don't see it and you can't trace it."

MICHIGAN MOPS UP
Thanks in part to rising environmental awareness, used

motor oil is beginning to get the attention it deserves — as both an environmental problem and a recyclable commodity. It wasn't so long ago that states were "oiling" dirt roads to control dust. But many of these states have now passed laws banning used oil from landfills, and they've instituted fines for improper disposal. A handful of states have even mounted impressive collection efforts.

Michigan's program started in 1979. Crude-oil prices were sky-high, and automakers were scrambling to design fuel-efficient cars. The Energy Crisis was in full bloom. Started as a volunteer project by Grand Rapids' non-profit West Michigan Environmental Action Council, the program's concept was simple: funnel DIY [Do-It-Yourselfer] oil into the existing collection system serving business and industry. The staff and volunteers recruited service stations, quick-lube shops, and car dealerships — places already equipped to handle oil. A small budget of \$25,000 paid for promotion materials, staff time, and a toll-free number directing DIYs to the nearest collection site.

They sponsored workshops on oil pollution and recycling, and recruited more collection sites. They packaged the tasks of education, recruitment, even building collection sites, into projects for youth groups such as 4-H. The coalition grew to include public health departments, environmental groups, the

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state's soil-conservation districts, and the business sector, all working to educate DIYs and maintain public collection sites.

While the number of collection sites continues to fluctuate (currently there are 567 in 62 Michigan counties), the amount of oil diverted has climbed every year, proof that people will recycle oil when they know how.

SLIPPERY ECONOMICS

These days, there's simply no money in collecting used motor oil from the public. The market value of used oil rises and falls with the price of virgin crude. In the late 1970s and early '80s, high oil prices spurred interest in used oil. The haulers that picked up used oil from service stations were paying for it. The private sector's profit motive was good news for recycling: Drop off that dirty old oil at my tune and lube? Sure! Then the bottom fell out of world oil prices during the "oil glut" of the mid '80s. Before long, haulers were charging to take used oil away. With the brief exception of the Persian Gulf War, the value of used motor oil has been sliding ever since, as has the number of collection sites in Michigan.

Volunteer operations are especially vulnerable to legal and financial perils. "Most of the newer recycling programs are institutionalized within state government," says Mr. Johnson, who looks to programs in Florida and Maryland as models of stability.

Florida looked at its used-motor-oil pollution and jumped. State environmental officials don't mince words about the potential threat of DIY oil: Groundwater lying just six or seven feet underground provides more than 90 percent of the state's drinking water. Kicking off the program last fall, then secretary of Florida's environment bureau Dale Twachtman said, "We estimate that around seven million gallons of oil from do-it-yourself mechanics are improperly disposed of each year in Florida. That's the kind of battering no state can take over a long period."

Florida backed its words with action, launching an aggressive public-education campaign (including a school-based program) and local and county-wide collection programs. In 1988-89, over \$1 million in grants went out to 54 counties, six cities, and one Indian tribe. "Everyone who requested a grant was funded," says Betsy Galocy, coordinator of the oil program. "The result was about 200 new collection sites." Counties and municipalities that operate collection sites also receive partial liability protection from spills or contamination, courtesy of the state.

Curbside collection programs now operate in Charlotte and Hernando counties; a third county, San Luce, features a mobile oil-collection vehicle, which serves 11 pickup points each month. Augmenting the

state's efforts, the oil biz has opened its tanks to DIYs. About 450 of Florida's 650 collection sites are Mobil, Amoco, BP America, and Texaco service stations.

BURN IT OR BOTTLE IT?

The durable qualities that make motor oil a fine lubricant also make it ideal for recycling. During its workout in the crankcase, additives in the oil may break down, and the oil darkens as it collects contaminants. Through the process of re-refining, these impurities are removed by heating and filtering, yielding "new" oil.

It used to be that virgin crude oil required no special processing — most oil in the world was of motor-oil quality when it came out of the ground. But as we've dipped deeper into the world's reserves, overall quality has declined. Producing motor oil from today's crude is a costly, elaborate process: 42 gallons of crude oil yield just 2.5 quarts of virgin motor oil, along with some other products. Re-refining, on the other hand, is much more efficient: Only one gallon of used oil is needed to produce the same 2.5 quarts of quality lubricant (plus by-products).

However, the vast majority of collected oil isn't re-refined. It's reprocessed. Reprocessing involves blending the used oil with virgin stock to make industrial heating fuel. About 80 percent of the DIY oil collected in the U.S. takes this

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route. Reprocessing has benefits — it reduces virgin-oil consumption and saves money — but in the eyes of some environmentalists, burning high-quality motor oil is no victory for recycling. “These are our finest-quality lubricating oils,” says Ms. Stoneman. “Reprocessing is better than dumping, but reprocessing is using that oil only once [more].”

There’s a good explanation for the mere trickle of oil that’s re-refined: Only seven re-refineries have been running in North America, and just three were considered sizable operations with current technology. And only one of those, Evergreen Oil of Newark, Calif., is in the U.S. The Evergreen plant takes in about 12 million gallons of used oil each year.

U.S. re-refining took a quantum leap this past April, though, with the opening of the SafetyKleen Corp. re-refinery in East Chicago, Ind. Outfitted with the latest technology and capable of processing 75 million gallons of used oil annually, the plant is the largest re-refinery in the world, and roughly triples U.S. capacity.

Small, independent re-refineries flourished years ago, and memories of the substandard products of that time haven’t disappeared. Skeptics question the overall consistency of “used oil” and say it can’t possibly be as reliable as new stock. But a spokesman notes that SafetyKleen oils have passed

the toughest tests, including the specifications for U.S. military machinery.

New York State is among the fans of re-refined. In 1990, the state bought more than 76,000 gallons for use by municipalities and school districts. “It was low bid, and it met our specifications,” says Steve Pryor, a purchasing officer in Albany. “We didn’t do anything different in purchasing procedures; the product simply became available.”

For used-oil recycling to gain even more momentum, says Julie Stoneman, action is needed on all fronts at once. Leaders at the state and local levels need the facts about used-oil pollution, and they need models for collection programs. The business sector needs to participate at both ends of the recycling cycle. “That means taking DIY oil if you’re a service station, and stocking re-refined oil if you’re a major retailer,” she says. And finally, more do-it-yourselfers need to realize just what it is they’re throwing away. Motor oil may originate in the Earth, but after refining and a 7,000-mile run in a crankcase, it shouldn’t be sent home again.

A Closer Look At Tires

Some 240 million tires are discarded annually in the United States. And billions of used tires are buried in landfills across the country. Considering it takes about half a barrel of crude oil to produce the rubber in just one truck tire, this is a waste of valuable resources. source: *50 Simple Things You Can Do To Save The Earth*

More than 50 percent of the nation's rubber is used to make tires.

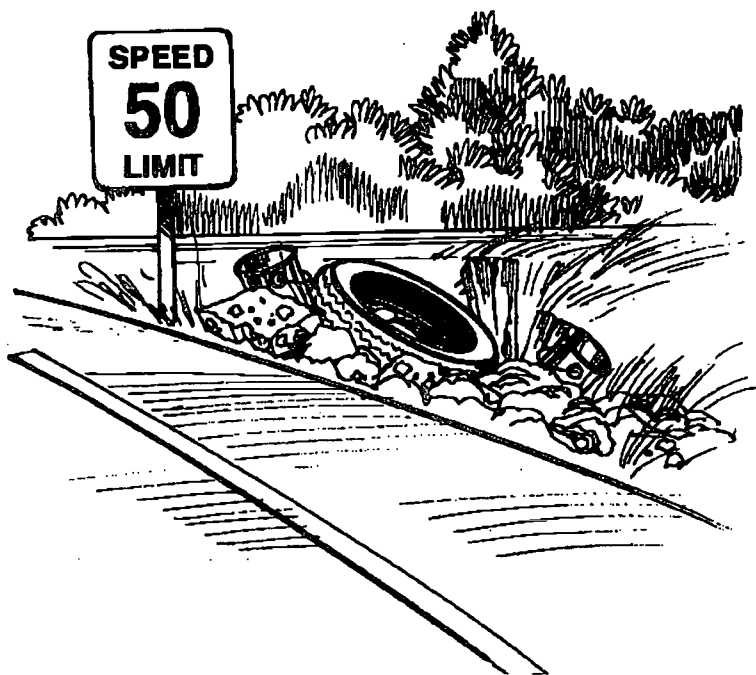
According to the U.S. EPA, *Summary of Markets for Scrap Tires*, scrap tire generation has grown by about 2 percent per year since 1984. Less than 7 percent of these scrap tires are recycled as products, approximately 11 percent are incinerated for their fuel value. Another 4 percent are exported, and the final 78 percent are disposed in landfills, stockpiled or illegally dumped.

What can we do about tires?

One of the best things to do is to keep your tires from becoming waste tires by taking care of them. Keeping tires properly inflated makes them last longer by reducing wear and saves fuel because tires roll with less resistance.

The typical American driver rides on under inflated tires – that's 65 million of us. Besides wearing tires out faster, underinflated tires decrease gas mileage by up to five percent.

Improvements in tire manufacturing over the past forty years have more than doubled the useful life of tires. Currently, steel-belted radial tires last about 40,000 miles. If tires are properly inflated, rotated, and otherwise properly cared for, 60,000 to 80,000-mile lifetimes can be achieved.



In 1991, the Department of Health and Environmental Control estimated that nearly four million waste tires were stockpiled in locations throughout the state. According to the U.S. EPA, 78 percent of all scrap waste tires are disposed of in landfills, stockpiled or illegally dumped. In South Carolina, whole used tires are banned from disposal in landfills.

Retreading is Recycling

In the past, recyclers turned old tires into new ones by retreading them. Retreading is the application of new tread to a worn tire that still has a good casing.

Currently over 1,900 retreaders operate in the United States, but that number is shrinking because of declining markets for passenger retreads. This decline is due to the relatively low price of new tires and concerns about the safety. Truck tires, however, are often retreaded three times before they are discarded, and the truck tire retreading business is increasing.

According to the Tire Retread Information Bureau, retreaded tires are processed according to the Federal Safety Standards developed by the U.S. Department of Transportation. Commercial aircraft retreaded tires are approved by the Federal Aviation Administration. This organization promotes tire retreading as a form of recycling.

In 1989, the U.S. EPA established buying guidelines for the government that promotes the use of retread tires.

Recycling Tires into ...

Recycling tires into new products is still a fairly untapped area. The energy used to produce a pound of virgin rubber is 15,700 Btus. Producing one pound of recycled rubber requires only 4,600 Btus – a savings of 71 percent.

Each year, approximately 3 percent of the total number of tires discarded annually are used to make crumb rubber that is recycled for adhesives, wire and pipe insulation, brake linings, conveyor belts, carpet padding, lawn mower and tracker tires, hoses, sporting goods and many other products.

Ground rubber pieces can be added to asphalt for paving roads, runways, playgrounds and running tracks. **Rubber added to asphalt is reported to increase pavement life by 4 or 5 times and reduce the amount of resurfacing materials required.**

Today's steel belted radials make recycling harder and rubber recyclers are turning to more creative outlets for recycled rubber.

Today only about 38 million of the 240 million scrap tires generated each year in the United States see a second life, according to Recycling Research, Inc.

Whole tires are used for erosion control, for highway barriers, as artificial reefs, and for playground equipment. Tires may be split or punched to produce floor mats, gaskets, dock bumpers, and shoe soles.

New markets for scrap tires are in development. Most people see fuel chips, known as tire-derived fuel, as the most promising short-term market and rubber-modified asphalt as the most viable long-term solution.

A study by the Scrap Tire Management Council identified these markets as well as facilities that burn whole tires for energy, as meeting its criteria of being

environmentally acceptable, economically feasible and capable of significantly reducing the volume of scrap tires.

According to the U.S. EPA, in the past three years, the use of scrap tires as a fuel has increased significantly. **Scrap tires make an excellent fuel because they have a heat value slightly higher than that of coal, about 12,000 to 16,000 Btus per pound.**

On a national basis, they represent a significant potential energy source. The U.S. EPA reports that tire burning facilities can meet federal and state emission standards.

Combustion facilities that currently use tires as fuel include power plants, tire manufacturing plants, cement kilns and pulp and paper mills. Although whole tires require lower processing costs as a fuel resource, most power plants are equipped to incinerate only tires shredded into tire-derived fuels.

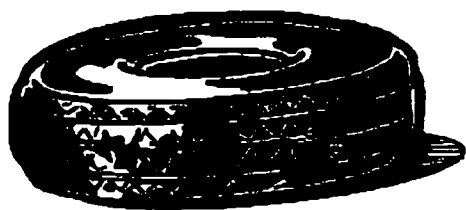
In several other countries – particularly West Germany, Austria, France, Greece and Japan – incinerating of tires is more common than it is here.

Hastening the development of alternate strategies in our country is legislation limiting or prohibiting the landfilling of tires.

South Carolina includes waste tires among seven wastes that are classified as "special wastes" that require separate management provisions by the Solid Waste Policy and Management Act. Whole waste tires are banned from disposal in municipal solid waste landfills.

In 1991, the Department of Health and Environmental Control (DHEC) prepared a report on waste tire management and disposal. It was estimated that nearly 4 million waste tires were stockpiled in locations around the state. In 1992, records indicate that

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GAS MILEAGE BY UP TO FIVE PERCENT.**



Keep Your Rubber on the Road

The best way to minimize personal tire waste is to buy long-lasting tires and keep them properly inflated, which will also increase your gas mileage by as much as five percent.

Rotate and balance your tires every 6,000 miles. If possible, buy tires from dealers who recycle old tires.

approximately 3.6 million *additional* waste tires were generated. If not adequately addressed, this solid waste management challenge would become a nightmare.

The Solid Waste Policy and Management Act establishes a \$2.00 fee on each new tire sold in the state. From this fee, monies are generated for distribution to each county for the collection and disposal of waste tires; for reimbursement of the administrative costs of the tire retailer or wholesaler; and for the establishment of the Solid Waste Management Trust Fund. Grants are funded to help local governments remove stockpiled waste tires and to develop waste tire management alternatives.

In 1993, 33,749 tons of waste tires were collected for recycling. Currently S.C. DHEC has approved more than 10 tire management facilities. These offer options that include waste tires as a fuel in boilers, using waste tires as a substitute for gravel in septic tank drain lines, and using tires to produce artificial reefs in the ocean.

Sources: Tire Industry Safety Council, P.O. Box 1801, Washington, DC 20013.

Tires Are Bouncing Back

Recycling Today, August 1991

The League of Women Voters Education Fund, Garbage Primer, 1993

A Closer Look At Hazardous Wastes

If you own a bicycle or a tennis ball, or if your family has a car, you have things that are made with materials that are considered hazardous if handled improperly. Hazardous wastes are a fact of modern life.

Hazardous wastes are byproducts of many manufacturing processes. **Hazardous waste can be a solid, liquid or gas.** About 10 to 15 percent of all waste generated in the United States is hazardous.

Hazardous waste has certain characteristics that make it potentially harmful. It may be **toxic, corrosive, ignitable or explosive.**

Medicines, televisions, computers, even tennis shoes – almost anything that you can think of that has been manufactured, contains hazardous materials of some kind or produced a hazardous byproduct when it was manufactured. Of course, this does not mean that the item itself is hazardous. For example, putting the colors in paints and fabrics generates hazardous waste. So does the manufacture of many metal, plastic, and even wood products. De-inking newspapers before they can be recycled produces a hazardous waste byproduct.

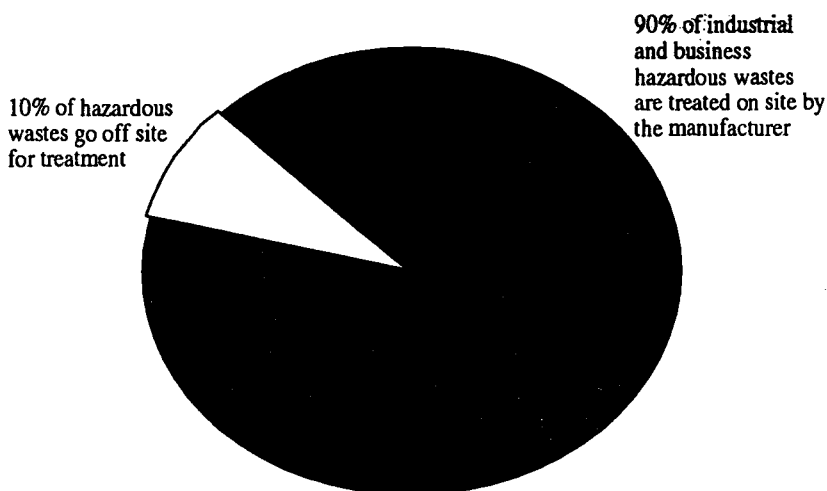
About 90 percent of the hazardous waste generated in the United States is treated right at the factory where it is created. The other 10 percent is taken to special federally regulated and permitted facilities for treatment. Hazardous wastes may be recycled, burned, treated with chemicals, or buried in a special hazardous waste landfill.

For every single person in the United States, about one ton of hazardous waste byproducts – the stuff that is left over after something is made – is generated *every year*.

Did you know that more than 100 separate hazardous materials are used just to make a bicycle, and about 50 separate hazardous materials are used to make one tennis ball?

According to the book, *Earth in the Balance*, by Vice President Al Gore, in the United States there are an estimated 650,000 commercial and industrial sources of hazardous waste; the U.S. EPA believes that 99 percent of this waste comes from only 2 percent of these sources. An estimated 64 percent of all hazardous waste (managed off site) is managed at only 10 regulated facilities. About 60 percent of all hazardous waste comes from chemical manufacturing, about 25 percent from the production of metals and machinery, 11 percent is divided between petroleum refining (3 percent) and 100 smaller categories.

Hazardous wastes must be handled carefully. There are laws to regulate how factories and businesses handle and dispose of their hazardous wastes.



Hazardous Waste Classifications

Ignitability - Ignitable wastes are liquids with a flash point less than 140°F for flammable gases, strong oxidizers or substances which burn vigorously under spontaneous circumstances. Besides potential hazards from fire, heat and toxic smoke, they can spread harmful particles over a large area.

Examples include solvents such as toluene, xylene and benzene; oils; plasticizers; and paint and varnish removers.

Corrosivity - Corrosive wastes are substances which can, upon contact, cause destruction of living tissues and materials by chemical action. They are generally water based wastes with a pH less than or equal to 2 (acids) or greater than or equal to 12.5 (bases). Because they may corrode standard materials, such as steel, corrosive wastes require special containers. Examples: alkaline cleaners and battery wastes.

Reactivity - These are wastes that are normally unstable, may spontaneously and vigorously react with air or water, be unstable to shock or heat, generate toxic gases when mixed with water and/or explode. Examples include obsolete munitions, cyanide- and sulfide-bearing wastes, and wastes from the explosives and chemical industries.

Toxicity - Toxicity is measured by the potential for a waste to release substances in sufficient quantities to pose a substantial hazard to human health, domestic livestock and/or wildlife through ingestion, inhalation or absorption. The U.S. EPA has identified maximum concentrations of heavy metals, pesticides and herbicides over which significant risk to human health may occur. These concentration limits are set at a level 10 times the U.S. EPA/Primary Drinking Water Standard.



Household Hazardous Waste

The average American stores three to 10 gallons of household hazardous products at any given time. Examples of household products which contain toxic or polluting chemicals include paints, septic tank cleaners, fingernail polish, drain cleaners, disinfectants, pool chemicals, pesticides, hobby supplies, car batteries and laundry bleach.

People are generally unaware of the potential dangers of using, storing and disposing of common household substances. Some potentially severe consequences of careless disposal of these products include:

- **pollution** of drinking water, ponds, harbors and rivers
- **injury** to trash collectors (chemicals when mixed together can cause fires, acid burns and the release of toxic fumes)
- **smog and other air pollution** is caused by evaporation of solvents contained in products such as household paints, varnish strippers and even fingernail polish
- **injury** to firefighters battling fires involving large amounts of flammable substances such as gasoline, paint thinner and pesticides
- **destruction of important bacteria** necessary to break down wastes in sewer and septic tank systems.

Hazardous Waste Around the World...

- Germany is home to more than 34,000 abandoned toxic waste sites.
- Industrial emissions blowing from China have caused severe acid rain throughout Japan. In a study in 1991, scientists found acidity in snow almost equal to that in orange juice.
- Battery recycling is done routinely in Europe and Japan.
- The United States and Canada maintain the highest environmental standards of any other countries in the world. Source: 1993 Earth Journal

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The most important law concerning hazardous waste is the Resource Conservation and Recovery Act (RCRA). Passed in 1976, it has been amended to tighten regulation of hazardous substances. RCRA:

- determines which wastes are hazardous
- creates rules for handling and disposing of these wastes
- makes sure wastes are transported safely if they leave the generation site
- makes sure any spilled or mismanaged wastes are cleaned up
- keeps track of all the hazardous wastes created in this country.

In 1984 RCRA was amended by the Hazardous and Solid Waste Amendments. These amendments changed the focus of waste management in many ways, including the development of minimum technology requirements.

The Comprehensive Environmental Response Compensation and Liability Act, or CERCLA, was enacted in 1980 and created a "Superfund" to provide money for cleanup of abandoned and/or inactive waste sites.

CERCLA was amended in 1986 with the **Superfund Amendments and Reauthorization Acts, or SARA.** These amendments provide additional money for cleanup, involve the public in decision-making processes, and encourage states to participate with the U.S. EPA to address these sites.

When we think of hazardous wastes and materials, we may think of chemicals and thick fumes. In reality, hazardous wastes are generated every day by industries, agriculture, the military, small businesses, public agencies, institutions, and homeowners. Originally RCRA was written to regulate hazardous waste produced by the **large quantity generators:** industries, agriculture, and the military. Large quantity generators generate more than 1,000 kilograms of hazardous waste per month.

RCRA has since been amended to regulate the previously exempted **small quantity generators** including small businesses, public agencies, and institutions such as schools, hospitals, and maintenance crews. Small quantity generators are those which generate less than 1,000 kilograms of hazardous waste in a calendar month. Some small quantity generators are conditionally exempt.

The small amount of hazardous wastes found in homes, **household hazardous waste,** has remained exempt from federal regulations.

Small businesses that are likely to produce hazardous wastes include those that: repair and maintain motor vehicles, electroplate materials, operate printing and copying equipment, perform dry cleaning and laundering services, process photographs, operate laboratories, construct buildings and roads, spray lawns and/or homes for pest control, preserve wood, make or refinish furniture, paint and clean buildings, clean and maintain swimming pools, repair air conditioners, and make and glaze ceramic pottery.

The actual amount of hazardous waste generated by a single small business or school may seem insignificant, but the amount from all these sources adds up to a profound threat to the environment if not properly handled.

To identify and properly manage the hazardous waste produced by small quantity generators (SQGs), South Carolina requires reporting annually by companies generating between 100 kilograms and 1,000 kilograms per month. For 1992, 1,046 small quantity generators reported.

Although the majority of small quantity generators are small businesses, many schools also generate significant amounts of hazardous wastes. Often, these wastes are improperly disposed by unknowing teachers, custodians, and clerical staff who pour hazardous wastes down sink drains, dump them on the ground or in storm drains, bury them in containers which can leak over time, or put

them in garbage cans or dumpsters for disposal in municipal landfills. Improperly managed hazardous waste can pollute our ground water, contaminate rivers and lakes, kill fish and other wildlife, pollute the air with toxic vapors, cause explosions or fires, and poison humans from direct contact or consumption of contaminated plants and animals.

Many hazardous waste generators – especially large quantity generators – treat, store, or dispose of wastes on site under federal and state regulations. The technology and equipment for this activity is expensive and usually too costly for small quantity generators. The most economical way for small quantity generators to manage their hazardous waste is to have it shipped to approved facilities.

Like any other kind of waste, the less hazardous waste a generator produces, the easier it is to manage. Small quantity generators can reduce the amount of hazardous waste they produce by recycling waste materials, participating in waste exchanges with other small quantity generators, and using alternative nonhazardous substitutes for potentially hazardous products. Hazardous wastes that can be recycled for further use include lead in car batteries, and silver from used photographic fixer. In many cases, one generator's hazardous waste can be another industry's raw material.

In our area, small and large quantity generators can call the Southeast Waste Exchange in Charlotte, North Carolina and list their wastes in a publication that is circulated to other generators, recyclers, and waste brokers.

Hazardous Waste in South Carolina

In March 1978, the General Assembly of South Carolina approved a regulatory program for the management of hazardous wastes. This legislation, known as the **South Carolina Hazardous Waste Management Act**, (Act 436) established the statutory framework necessary for the South Carolina Department of Health and Environmental Control, DHEC, to regulate hazardous waste activities within the state.

There are five (5) major elements in the state's approach to hazardous waste management: (1) classification of hazardous wastes; (2) cradle-to-grave tracking (manifest system); (3) quarterly reporting; (4) standards to be followed by generators, transporters, and facilities which treat, store or dispose of hazardous waste; and (5) enforcement of standards for facilities through a compliance monitoring, enforcement and permitting process.

A method of establishing wastes as hazardous involves the listing of specified industrial activities or substances presumed to be hazardous.

These categories are:

Wastes From Non-Specific Sources - wastes of the same genetic type used universally as multi-purpose chemicals, for example halogenated solvents.

Wastes From Specific Industrial Processes wastes generated by a specific industry, for example distillation bottoms from the production of acetaldehyde from ethylene.

Off-Spec Commercial Chemicals wastes from off specification materials, discarded commercial chemical products, container residues and spill residues including:

- about 200 chemicals considered "acutely hazardous" and regulated if more than 1 kilogram per month is generated.
- about 400 chemicals subject to regulations.

The state also includes a listing of hazardous wastes which are not properly identified by any existing or valid waste number.

Once wastes are identified as hazardous, their generation, transportation, treatment, and storage or disposal are managed. Minimum standards are specified in DHEC's regulations for each of these management categories. These standards include record keeping; facility design, construction, and operational requirements; permitting procedures; financial responsibility; and compliance self monitoring where applicable.

DHEC's staff responsible for implementing this program consists of engineers, hydrologists, chemists, geologists and other technical and clerical employees. These personnel are responsible for all hazardous waste activities including program administration; permitting; public participation compliance and surveillance; enforcement; field inspections and investigations; emergency response to spills and releases; and cleanup activities at uncontrolled sites.

Volume of Hazardous Wastes in South Carolina

Hazardous waste volume figures include significant amounts of hazardous wastewater. According to *Hazardous Waste Activities Reported for South Carolina for 1993* published by DHEC, 177,647 tons of the total 323,341 tons of hazardous waste generated in 1993 were hazardous wastewater.

In 1993, South Carolina generators shipped 155,514 tons of hazardous waste off-site. A total of 312,892 tons of hazardous waste were received by commercial off-site facilities in Carolina from in-state and out-of-state sources. As these figures indicate, **South Carolina is a net importer of hazardous wastes.**

According to the 1993 Hazardous Waste Activities Report, in general most of the hazardous wastes generated by

Using Cleaning Products Safely

The safest cleaners of all reside in many of the products you already have at home: baking soda, vinegar, lemon juice, vegetable oil, borax and hot water, for example. If you are unable to substitute a safer cleaning product for a hazardous one, it is important to follow these safety steps.

- Read all labels carefully before using hazardous products. Be aware of their uses and dangers.
- Leave products in their original containers with the label that clearly identifies the contents. Never put hazardous products in food or beverage containers.
- Do not mix products unless instructed to do so by label directions. This can cause explosive or poisonous chemical reactions. Even different brands of the same product may contain incompatible ingredients.
- If you are pregnant, avoid toxic chemical exposure as much as possible. Many toxic products have not been tested for their effects on unborn children.
- Avoid wearing soft contact lenses when working with solvents and pesticides. They can absorb vapors from the air and hold the chemicals near the eye.
- Use products in well-ventilated areas to avoid inhaling fumes. Work outdoor whenever possible.
- Do not eat, drink or smoke while using hazardous products. Traces of hazardous chemicals can be carried from hand to mouth. Smoking can start a fire if the product is flammable.
- Make sure containers are kept dry to prevent corrosion.
- Store volatile chemicals or products that warn of vapors or fumes in a well-ventilated area, out of reach of children.
- Store gasoline only in approved containers, away from all sources of heat, flame or sparks in a well-ventilated area.
- Store rags used with flammable products (including furniture stripper, paint remover and gasoline) in a sealed container.

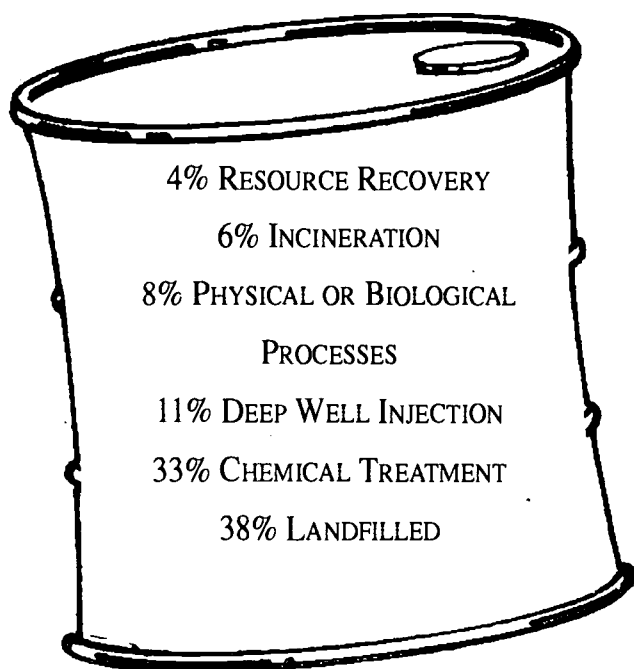
South Carolina companies remained in the state to be treated on-site or by commercial off-site facilities within the state. As much as 80 percent of the hazardous wastes commercially treated, stored, disposed, or recovered by South Carolina facilities were received from sources outside the state. The remaining 20 percent were received from South Carolina generators. Approximately two-and-one-half times as much waste is being shipped into South Carolina compared to what is shipped out from the state.

Hazardous Waste Facilities

South Carolina has one commercial hazardous waste landfill, one of only two facilities in the Southeast. The hazardous waste landfill is located outside of Pinewood in Sumter County and is operated by GSX Services of South Carolina, Laidlaw Environmental Services, Inc. The state also has two commercial hazardous waste thermal treatment facilities, incinerators, ThermalKEM, a fixed-hearth facility in Rock Hill, and Thermal Oxidation, (also Laidlaw Environmental Services, Inc.) a liquid injection system in Roebuck, outside Spartanburg.

Hazardous Waste Management

Percentages of total hazardous waste in the U.S.
Methods of treatment and disposal



Household Hazardous Wastes

According to experts, products may not be hazardous while they are being used, but they can become hazardous when they are burned, poured down the drain or disposed of improperly.

There is a difference between hazardous products and those that can become hazardous and are

dangerous. For example, household bleach may seem harmless, but if mixed with ammonia, it creates toxic fumes. Batteries are harmless in appliances but are not welcome in landfills.

While businesses and manufacturers are carefully monitored, **there are no laws to regulate how households handle their hazardous wastes.** This is why it is so important that people understand the potential risks to health and the environment of the household hazardous products they may purchase, use and store.

According to the article "Horror in the Basement," *Recycling Today* magazine, August 1991, Americans are left to police their own contributions to the hazardous waste stream. The result is a jumble of state and community laws, random hazardous waste collections and hosts of opinions on how risky household chemicals are to human health.

People seem to agree on the facts, but clash on their perceptions of the problem. Industrialists want more recognition for developing less-toxic products; environmentalists frown on any toxins lining the store shelves. "Green" citizens are aghast when neighbors use products such as chemical drain cleaners; their neighbors, in turn, shrug at all the fuss made over the seemingly irreversible existence of chemicals in the household. Many

environmentalists view hazardous waste landfills as bad; while others see them as good and necessary.

Household hazardous waste may contain the same hazardous components of industrial hazardous waste; but because of the small volumes, it is difficult to account for in state statistics.

According to Environmental Health Watch in Cleveland, Ohio, each person may be responsible for generating 15 pounds of household hazardous waste each year.

In household hazardous waste collection programs, each household brings in an average of 100 pounds of these materials, according to WasteWatch, a national clearinghouse on household waste.

DHEC sponsors household hazardous waste collections at various times and has ongoing provisions for recycling used oil and lead-acid car batteries. Large commercial waste operators also sponsor household hazardous waste collections.

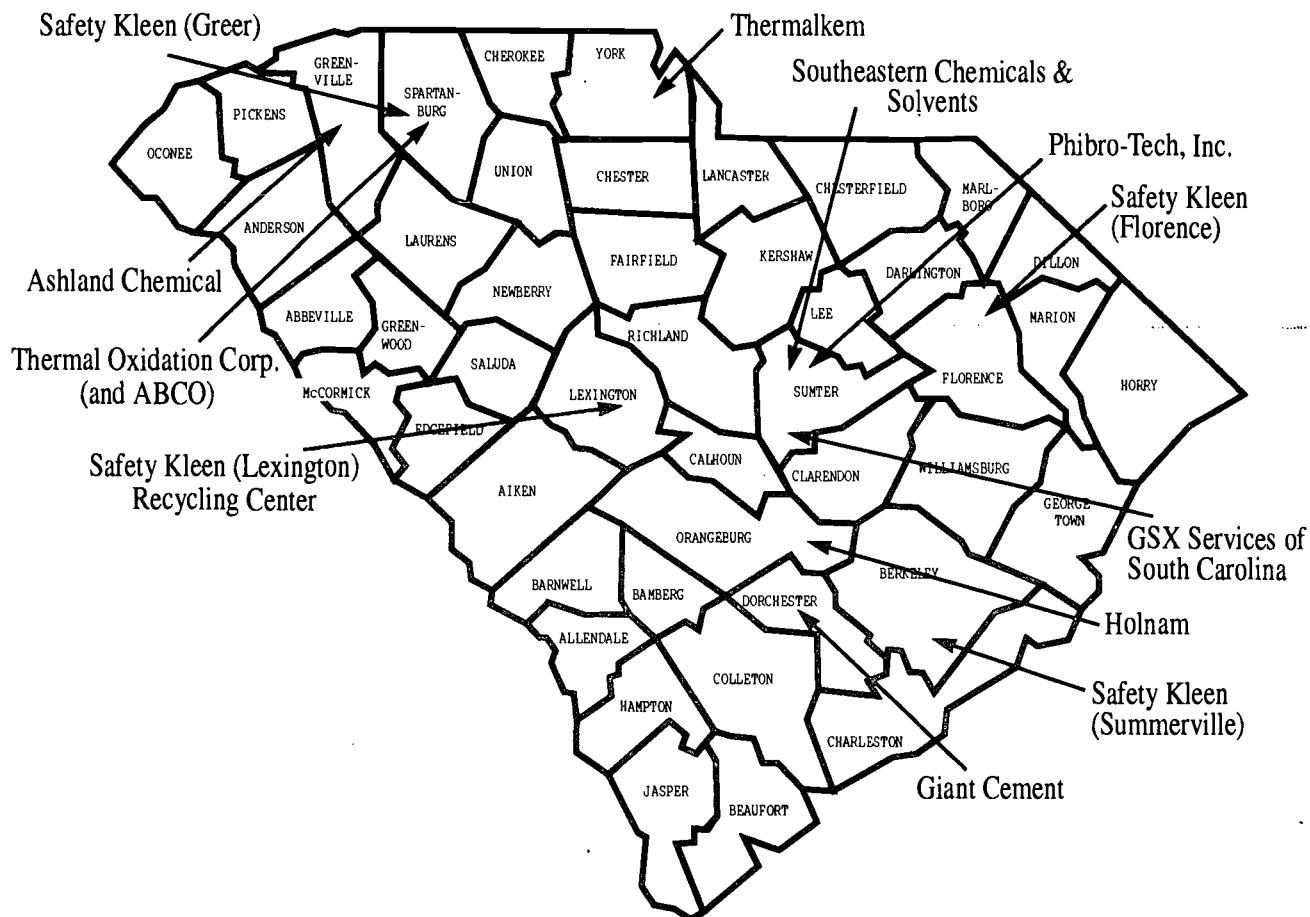
Examples of household hazardous waste include paint thinner, batteries, drain cleaners, poisons, pesticides, fertilizers and other cleaning and chemical-based products.

When used safely for their intended purpose, the vast majority of these products present few concerns. But when used improperly or when containers pile up in basements, garages and barns, they are dangerous. And if they get poured down the drain or put into the household trash, they can become a dangerous source of pollution.



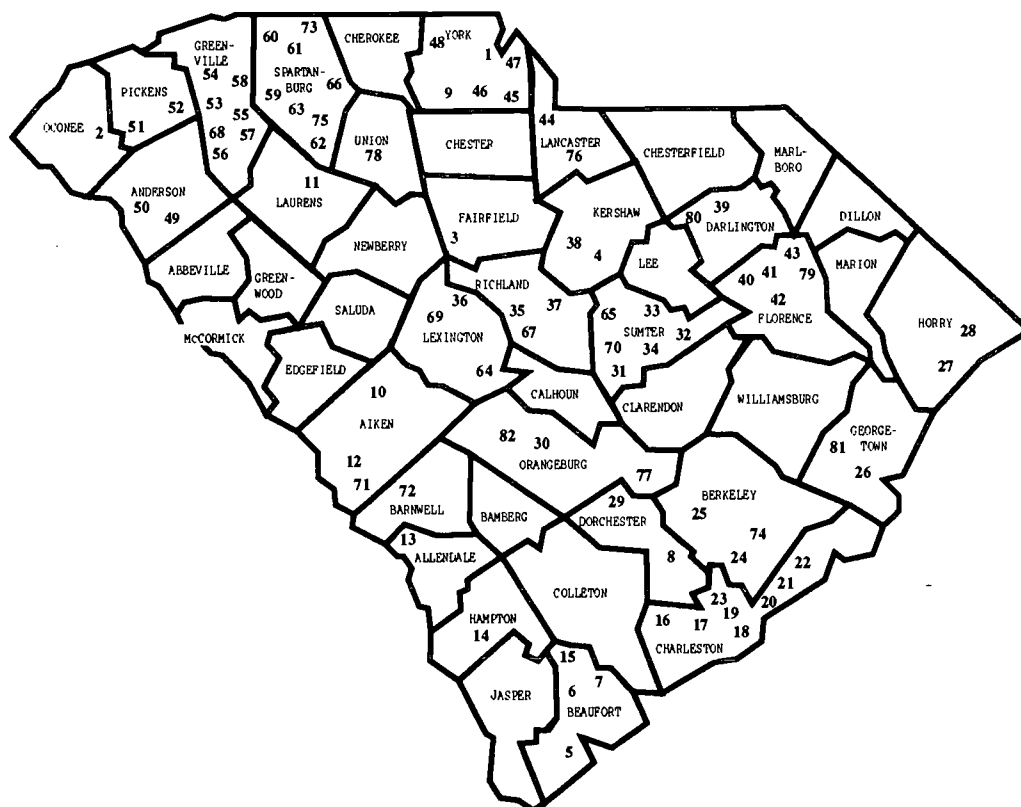
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STATISTICS.**

MAJOR HAZARDOUS WASTE COMMERCIAL OFF-SITE FACILITIES IN SOUTH CAROLINA, 1993



source: South Carolina Department of Health and Environmental Control,
Office of Environmental Quality Control, Bureau of Solid and Hazardous Waste Management

Locations of South Carolina's Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities



Key

1. Duke Power
2. Duke Power
3. SCE&G
4. Hardwicke Chemical
5. USMC Recruit Depot
6. NWL Controls
7. USMC Air Station
8. Safety-Kleen
9. Leonard Chemical Co., Inc.
10. FMC Corp. - Ground Systems
11. Torrington
12. SRS M. Area
13. Sandoz Martin Works
14. Westinghouse Electric Corp.
15. Le Creuset of America
16. Stoller II
17. Lockheed-Georgia
18. North Hand Protection
19. Moore Drums, Inc.

20. Medical University of S.C.
21. Albright & Wilson, Inc.
22. USN Chas. Weapons Station
23. USAFB Charleston
24. US Naval Shipyard Chas.
25. E.I. DuPont de Nemours
26. Georgetown Steel Corp./GE
27. USAF Myrtle Beach
28. Wol. Brass Works/D. Walthe
29. Giant Cement Co.
30. Cox Wood Preserving Co.
31. GSX Services of S.C.
32. SE Chemical & Solvents
33. Southern Coatings Inc.
34. C.P. Chemicals, Inc.
35. Owen Electric Steel Co.
36. Allied Corporation
37. USA R. Jackson ATC
38. E.I. DuPont de Nemours
39. Intl. Minerals & Chemical Co.
40. ESAB Welding Products, Inc.
41. General Electric Co.
42. Safety-Kleen
43. Koopers Company, Inc.
44. So. Screen Engravings, Inc.
45. Landfill, Inc.
46. Thermalkem, Inc.
47. Hoechst-Celanese
48. North Hand Protection
49. Owens Corning Fiberglass
50. Eliskim Inc.
51. BASF
52. Platt Saco Lowell Corp.
53. Carolina Plating Inc.
54. T&S Brass & Bronze Works
55. Steel Heddle Mfg. Co.
56. Roy Metal Finishing Co.
57. G.E. Gas Turbine
58. American Hoechst Corp.
59. Safety-Kleen
60. Milliken Chemical Dewey
61. Southern Wood Piedmont Co.

62. MEMC Elec. Materials, Inc.
63. Siemens Energy & Automtn.
64. Gaston Copper Recycling
65. USAFB Shaw
66. Blackman-Uhler Chem. Div.
67. Ashland Chemical Co.
68. Ashland Chemical Co.
69. Safety-Kleen
70. USAF Poinsett Range
71. SRS F. Area
72. SRS H. Area
73. Hudson Wire
74. Miles, Inc.
75. Laidlaw Environmental Ser.
76. Thomas & Betts, Inc.
77. Holnam
78. Torrington
79. DuPont
80. CP&L
81. VVV
82. Ethyl Corporation

A Closer Look at Composting

Composting is nature's recycling. The U.S. EPA includes composting in its definitions of **recycling**. In composting, the natural process of decomposition recycles organic material into a humus-rich soil amendment. Compost looks, feels and smells like soil.

In this country, approximately 30 percent of our household trash is yard clippings and kitchen scraps and as much as 70 percent of our trash is organic material that can be composted. If composted instead of thrown away, this waste would provide a useful resource instead of filling up our landfills.

When yard wastes are thrown away and taken to the landfill, the organic matter reacts with other materials and creates toxic leachate that may contaminate groundwater.

For areas that send their garbage to waste-to-energy facilities for incineration, yard waste is also problem. With its **high** moisture content, yard wastes reduce the efficiency of these operations.

Yard wastes and other trash should never be burned at home. Even if your community does not pick up yard waste for composting or disposal, do not burn it. Burning yard wastes causes air pollution from carbon dioxide and nitrogen oxide.

What To Do With Yard Wastes In South Carolina

In South Carolina, the Solid Waste Policy and Management Act forbids the disposal of yard waste and land-clearing debris in municipal solid waste landfills after May 27, 1993.

This means that yard trash must be handled separately from your household garbage. Do not put yard trash such as leaves, branches, or grass clippings in your trash can. These items should be kept separate for pick up. Communities will differ in how they pick up and handle yard wastes.

Local governments can compost, shred for mulch or dispose of yard waste in a permitted construction, demolition and land-clearing debris landfill. **South Carolina has 60 registered composted/chipping facilities.**

No matter how your county handles yard wastes, yard wastes should not be mixed at the curb with other trash of any kind (no broken bricks, old wood, or other materials.)



The First Compost

Composting has been occurring naturally for millions of years ... as leaves fall from the trees to the forest floor and slowly decay.

The first recorded use of compost to improve the soil was organized by the Roman Statesman Marcus Cato more than 2,000 years ago. A scientist and farmer, Cato developed a formula for compost that would turn animal manures and vegetation into useful soil builders.

Today, we know that compost improves the soil structure, texture and aeration and increases its ability to hold water. Composting is an accelerated version of the natural decay process. Left to decay naturally, leaf waste can take approximately two years to form humus. In a compost pile, it can take as little as 14 days.

Compost loosens clay soils and helps sandy soils retain water. Adding compost to soils aids in erosion control, promotes soil fertility and helps keep plants healthy. In fact, compost can replace the need to use many fertilizers.

RESOURCE SECTION 65

Three types of Composting

There are three types of composting.

1. **Nature's recycling** that occurs naturally on forest floors. This way nature replenishes itself and returns nutrients to plants and trees.
2. **Home/backyard composting** has been practiced by gardeners for years, turning garden and yard trimmings into a rich soil enhancer. Organic materials are usually collected in a pile or compost bin. Air, water and heat help break down materials into humus that's used for next year's planting.
3. **Municipal composting** is backyard composting on a much larger scale. Communities pick up yard wastes in special containers and compost it at large central facilities. Many communities sell the resulting compost to local gardeners and also use it for public parks, highway construction, land reclamation and other projects.

Composting: A Never-ending Solution

Unlike landfills that are reaching capacity, a composting site can be continually reused without reaching capacity. If properly managed, municipal composting is sanitary and produces no offensive odor problems.

Right now the biggest roadblock to composting is lack of awareness about the difference it can make in reducing our solid waste problems and lack of understanding about just how easy it is to start composting.

How the Compost Pile Grows

1. Where you live makes a difference in the best spot for your compost pile. In dry climates the best spot is under a tree. This keeps the pile moist and lets sunshine in part of the day. However it is best to avoid placing your compost pile under trees which produce acids that inhibit plant growth. In the south this means not placing your compost pile under a pine, eucalyptus, bay laurel, juniper, acacia, black walnut or cypress tree.

There are many different forms of composting. You will need to decide what materials you want to compost first before deciding on a composting bin.

Select a composting bin that meets your needs or simply enclose an area with wire. (To make mulch from yard clippings you only need to designate a spot to spread out the material.)

2. Items suitable for composting include biodegradable organics such as grass clippings, leaves, wood chips, vegetable and fruit peelings and cores, coffee grounds and egg shells. Even used paper that can't be recycled (paper towels and napkins, paper plates and egg cartons) can be shredded and added. Since these items are not laminated they will break down completely. To prevent your pile from attracting pests do not compost meat scraps, bones, fish or dairy items.

3. Collect kitchen scraps in a small covered bin. Empty it into your pile every few days. Hardware and garden supply stores sell special bins for collecting kitchen scraps.

4. To speed the process of composting, chop, crush or shred all materials before adding them to your compost pile. Also spread out grass clippings and yard wastes.

5. Put new materials into the center of the pile where it is the hottest.

6. The temperature will rise as the materials begin to break down.

7. Turn the pile every few days with a pitch fork. The more you turn, the higher the oxygen level and the faster decomposition occurs.

8. Water the pile occasionally to moisten it, but do not over water.

9. In several weeks the compost will be ready. If you don't turn the pile, decomposition will take longer.

In colder months it may take longer to break down materials into humus.



For more information about composting, call your local Clemson Extension Service office.

Keep On the Grass

Bagging grass clippings is not necessary to maintain your lawn. New mulching mowers chop grass clippings and deposit them back in the grass to help fertilize the lawn. Grass clippings are 20 to 30 percent protein and usually contain about four percent nitrogen, two percent potassium and 0.05 percent phosphorus.

If you don't have a mulching mower, adjust your mower to remove no more than one-third of the grass surface at any one mowing.

How Much Time Will It Take?

The time it takes to prepare and maintain a compost pile for your yard wastes is about the same amount of time that it would take you to bag grass clippings and leaves, tie the bags, place them in trash cans and take them to the curb. If you compost kitchen scraps, add a few minutes.

How the Compost Pile Grows

Soil: contains microorganisms that help decomposition.

Organic Wastes: leaves, food scraps and grass clippings. Wastes should be varied including materials with high carbon and high nitrogen content. By alternating these materials you create good environmental conditions for decomposition.

Nitrogen: many of the organisms responsible for decomposition need nitrogen. Nitrogen is found naturally in many organic wastes, such as manure and green grass clippings.

Carbon: brown materials such as dead leaves, straw and saw dust.

Worms: they eat waste, helping to break it down. Worms make droppings that enrich the soil and tunnel through and aerate the waste. As the worms eventually die, they become part of the compost.

Water: necessary for normal functioning of life. Too much water in a compost pile may make it soggy and slow to decompose.

Air: the biological activity of fungi, bacteria, small insects and organisms results in decomposition. Most biological processes require oxygen.

Time: decomposition takes time. To speed it, aerate your compost pile every few days.

Heat: heat is produced by chemical reactions resulting from increased biological activity that occurs during decomposition. Heat helps sanitize compost by killing certain organisms such as weed seeds and harmful insect larvae.

Mass: to generate enough heat for optimal decomposition, the pile must contain at least one cubic meter of organic material. The temperatures generated in a small pile are different than those generated in one that is larger.

You can make a ton of compost at home in an area only 4 feet square.

A Formula For Success

There are many recipes for compost. The most important thing to remember is to balance nitrogen- and carbon-rich materials. No nitrogen means that the pile will not generate heat needed for rapid decomposition. One-quarter to one-half green (nitrogen) materials and one-half to three-quarters brown (carbon) materials will heat up and rapidly decompose.

Composting's Rs

Composting **reduces** the amount of trash you generate. You can **reuse** the compost in your yard. The compost **recycles** nutrients back into your soil and plant life. Increased plant growth helps to **restore** the health and beauty of our neighborhoods.

source: Backyard Composting

Harmonious Technologies

If your compost has too much green material and not enough

brown, it may begin to give off an ammonia odor. This is easily corrected by adding brown material.

Compost is most active when the ratio of carbon to nitrogen is 30:1. For example the ratio of carbon to nitrogen in leaves is 60:1. Compost can be made from leaves alone, but if two parts grass clippings are mixed with one part leaves, the process will be faster and will result in a more fertile product.

A Closer Look At Landfills

Landfills are enormous holes in the ground where garbage is dumped and buried.

A majority of our solid waste is buried in what are known as **sanitary landfills**, specially designed areas that are lined and covered to prevent landfilled wastes from harming the environment.

According to the U.S. EPA, about 6,000 solid waste landfills operate in the United States. South Carolina has experienced major changes in the disposal of solid waste over the last several years. Until recently, almost every county owned and operated a landfill that was used for municipal solid waste. With the passage of new federal landfill laws, South Carolina is experiencing a dramatic decrease in the number of landfills owned and/or operated by individual local governments. Currently, South Carolina has about 39 municipal solid waste landfills. The state has only eight municipal solid waste landfills that are permitted and meet federal regulations.

As the number of municipal solid waste landfills continues to decrease, many counties will explore options to transport waste to disposal facilities outside their areas. Because of this, the number of transfer stations has increased to 21 stations.

South Carolina is also the site of one of the nation's 32 commercial hazardous waste landfills. The landfill, operated by GSX Services of South Carolina - Laidlaw Environmental, is located in Pinewood.

According to the 1993 South Carolina Solid Waste Management Annual Report, South Carolina disposed of 4.4 million tons of solid waste in municipal solid waste landfills and 1.3 million tons of solid waste in other landfills for a total of 5.7 million tons of landfilled waste in 1993. Also, 330,219 tons of solid waste were incinerated in solid waste combustion facilities.

From Your House to the Landfill

According to figures from the National Solid Wastes Management Association in their publication, *At A Glance*, approximately 8,000 municipalities and private trash haulers pick up our country's garbage using 140,000 refuse collection vehicles. At present, private refuse companies serve around 60 percent of all households and remove more than 90 percent of the nation's commercial refuse. Most of this waste is deposited in landfills. A fee is paid to the landfill operator based on how much trash a truck carries. This fee is called a tipping fee because the trucks lift their loads to tip them on the face of the landfill. As landfill construction, maintenance, and operation costs have increased, tipping fees have increased. South Carolina's average tipping fee is \$16.33. At the landfill waste materials are unloaded, spread out and compacted by bulldozers into waste cells. Daily, the waste is covered with earth.

Several layers of waste make up a landfill cell. A cell is typically one part soil to four parts waste. Cells are built side by side and on top of each other until the landfill is filled. When a cell is filled, it is closed by covering the layers of dirt and waste with a clay cap and packing it into a solid surface. Soil is then layered over the clay. When a landfill is completely filled, two to five feet of additional impermeable soil is placed over it; and grass, plants, and trees are planted on top. Completely closed landfills are monitored after they are closed and the land is available for other use. In South Carolina, Greenville Technical College is located on the site of a closed municipal landfill.

Nationally, the amount of waste going to landfills has decreased in the last few years from 84 to 76 percent of total wastes. In South Carolina, it is estimated that 60 percent of our wastes are landfilled. Even with current strategies to reduce waste, the U.S. EPA predicts that landfills will still be receiving about 50 percent of the waste stream by the year 2000. One reason landfills remain popular is that they are cheaper to operate per ton of waste than incinerators or recycling plants.

RESOURCE SECTION 69

Too Much Trash and Not Enough Space

Many parts of the country are now facing shortages in landfill disposal capacity. The U.S. EPA estimates that, between 1978 and 1988, 70 percent of our country's landfills – 14,000 facilities – closed. By 1995, predictions are that half of the remaining landfills will reach capacity and close, leaving large volumes of refuse without local disposal options.

This situation is a result of many factors including:

- a 34 percent growth in population since 1960
- an increasing volume of waste generated per person – up 1 percent each year
- many old waste incinerators were forced to close because they did not meet the guidelines of the Clean Air Act
- few new landfills are being built.

New Regulations for Landfills

In addition to these factors, new U.S. EPA Subtitle D regulations (part of the Resource Conservation and Recovery Act, RCRA, initially passed in the 1970s and amended to provide strict regulations for landfills) are coming into effect.

New regulations require installing plastic and clay liners, collecting and treating liquids that settle to the bottom of landfills (leachate), monitoring groundwater and surface water for harmful chemicals and monitoring for methane gas.

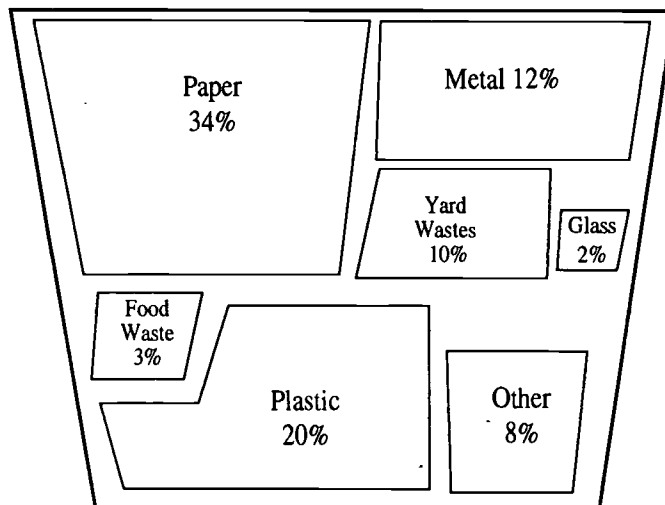
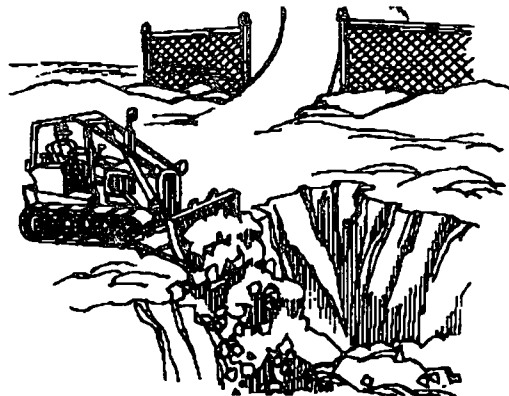
These new regulations will force landfill operators to either upgrade their systems or cease operation.

Estimated costs of building and maintaining a landfill that meets the new regulations are as much as \$125 million, according to the *1993 Information*

Please Environmental Almanac.

Landfill Volumes

Although the amount of waste we generate is usually reported in weight, landfill operators are concerned with waste volume, or the space that materials occupy in the landfill. The space materials occupy in the landfill is not directly related to weight.



source: National Solid Wastes Management Association, *At A Glance* newsletter, 1991

In South Carolina, all municipal solid waste landfills are required to meet the more stringent standards or close.

Several counties considered the financial commitment involved with the upgrade and decided to close their landfills and dispose of their solid waste at municipal landfills located in other counties. To reduce transportation costs to out-of-county landfills, many counties decided to construct transfer stations where solid waste is compacted prior to shipping.

The siting of new landfills is hampered by the environmental track record of dumps. More than 20 percent of the 1,200 cleanup sites on the Superfund National Priority List are old garbage dumps. These are sites where waste is polluting land and water resources. Some Superfund sites cost as much as \$30 million to clean up.

Modern landfills are designed to keep garbage in and keep pollutants from entering the environment. According to information presented in *The Garbage Primer* published by the League of Women Voters, landfills that meet federal standards lessen the environmental risk.

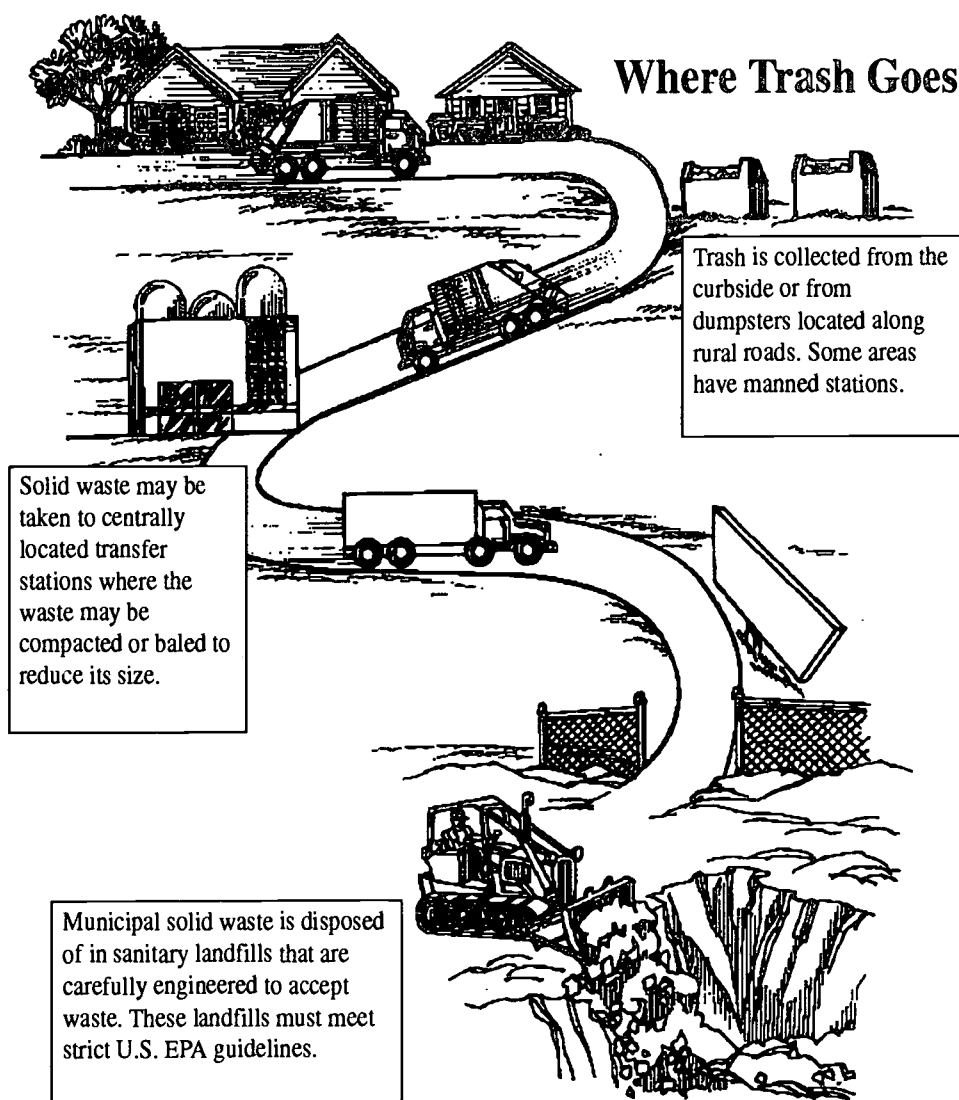
In addition to construction requirements, Subtitle D of RCRA requires

landfill owners/operators to monitor water sources and to maintain a leachate collection system and a final cover (a 4-foot cap of soil or a combination of soil and synthetic material) for a minimum of 30 years after the landfill closes. This maintenance requirement is critical, since even the most well designed landfills may eventually deteriorate.

Gases generated from landfills are also an environmental concern. The primary gases emitted from

landfills are carbon dioxide and methane. Methane is an odorless, explosive gas that is produced as organic matter decomposes under anaerobic (airless) conditions. Methane poses a health risk because it is explosive. Also it is a greenhouse gas and may contribute to global warming. Landfill gas also contains small quantities of other volatile organic compounds such as benzene and vinyl chloride. Methane monitoring is required under Subtitle D.

Leachate, the liquid that settles in landfills, can contain a broad range of chemicals, including lead, cadmium, and mercury. The amount of leachate generated by a landfill is influenced by precipitation, topography, facility design and

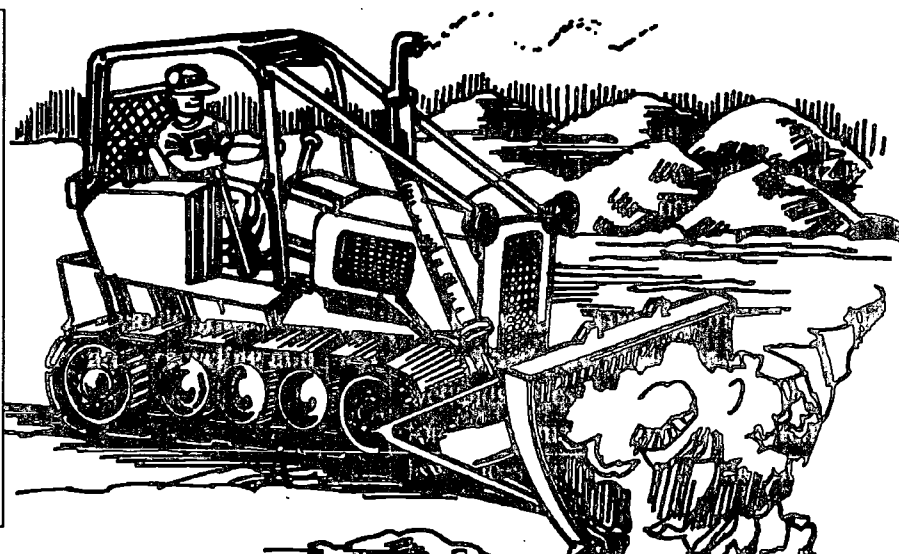


RESOURCE SECTION 71

Layers of the Landfill

Today's sanitary landfill is engineered to protect public health and the environment.

Subtitle D of the Resource Conservation and Recovery Act (RCRA) establishes standards that municipal landfills must meet.



Top Cap - The top cap of a landfill must be covered with:

- 2 ft. thick soil cover
- Drainage layer
- Flexible membrane layer of 60 mil HDPE plastic*
- 18" minimum clay liner (1×10^{-5} cm/sec max)
- Gas management layer

Waste Cells with operational cover

Bottom Liner - The landfill must have a protective bottom liner system that includes:

- 2 ft. protective layer of soil
- Leachate collection system
- Flexible membrane liner (60 mil HDPE plastic*)
- 2 ft. clay liner (1×10^{-7} cm/sec)

* Other materials may be substituted for HDPE plastic.

Note: For a full-color classroom poster, "The Anatomy of a Landfill," contact Santek Environmental, 1306 S. Lee Highway, Cleveland, Tennessee 37311, 1 800 467-9160.

operation, and the final vegetative cover. Landfills must install a groundwater monitoring system and set aside money to pay for any groundwater cleanup. A groundwater monitoring system consists of a series of wells located near the landfill that are sampled for the presence of contamination from the landfill.

A total of 400 million cubic yards of waste are landfilled in this country after recycling and combustion.

A Modern Landfill is No Dump

Well-engineered disposal facilities have little in common with the open dumps of the past.

Until recently, it was believed that waste decomposed completely in landfills. But studies of old landfills have proven that landfills – because of their liner systems and soil and clay covers – actually preserve garbage. In a landfill there is little if any air or sunlight, and things do not break down easily. Professor William Rathje of the Department of Anthropology at the University of Arizona examined waste buried in a landfill for 15 years or more and found newspaper you could still read and chicken bones with meat on them.

Our modern landfills do not permit much decomposition, therefore it is essential that the waste that can decompose, such as yard wastes, be disposed of in a system designed for biodegradation such as a compost pile.

How Garbage was Handled and Disposed in the Past

Trash disposal is an ancient problem that has typically been dealt with in the cheapest, quickest way. From the 1700s until the mid-1950s, communities relied on open burning and dumping as methods for solid waste disposal. Trash was disposed of in unpopulated areas considered unfit for development, such as river banks, wetlands, floodplains, marshes, swamps and bogs.

By the mid-1800s unsightly dumps were causing a number of health problems such as attracting

rodents and other pests which transmit infectious diseases. As populations grew, so did refuse accumulation, and the question of what to do with household garbage went unanswered. By the late 1800s, some communities passed ordinances to clean up refuse areas, but there were no laws regulating manufacturing wastes.

At the turn of the century, most communities in the United States dumped their waste in marshes and wetlands. These areas were considered unsuitable for development and could be purchased at very low prices by local haulers and municipal governments. The prevailing belief was that the soil would act as a natural filter, and that as the waste residues percolated through the ground, the dilution process would render waste harmless.

No one anticipated the consequences of groundwater contamination and the effects on public and private water supplies of dumping trash.

Garbage dumps were frequently established in areas where supplies of fresh groundwater are “recharged” by rainfall, the same places where many municipalities were also locating drinking water pumps and wells.

In the 1930s much waste was burned in open pits to reduce its volume before burial. Open pit burning, however, caused its own problems and there were frequent landfill fires. First, surrounding neighborhoods lived with continuously smokey air. Second, the fire department always seemed enroute to put out landfill fires. In fact, landfill fires used to be so abundant that they were used by fire departments to train newly-enrolled firefighters.

As the need for disposal grew, the availability of marginal land for disposal decreased and many cities built incinerators, further reducing the need for land to bury garbage. With household garbage piling up, industrial wastes were also accumulating as the demand for new “convenience” consumer goods grew.

From 1900 to 1948 although the industrial revolution was in full swing, no significant environmental legislation was passed. By the time people learned that waste management of harmful industrial byproducts was needed, millions of tons of chemicals and other wastes had already been released into our air, water, and onto our land.

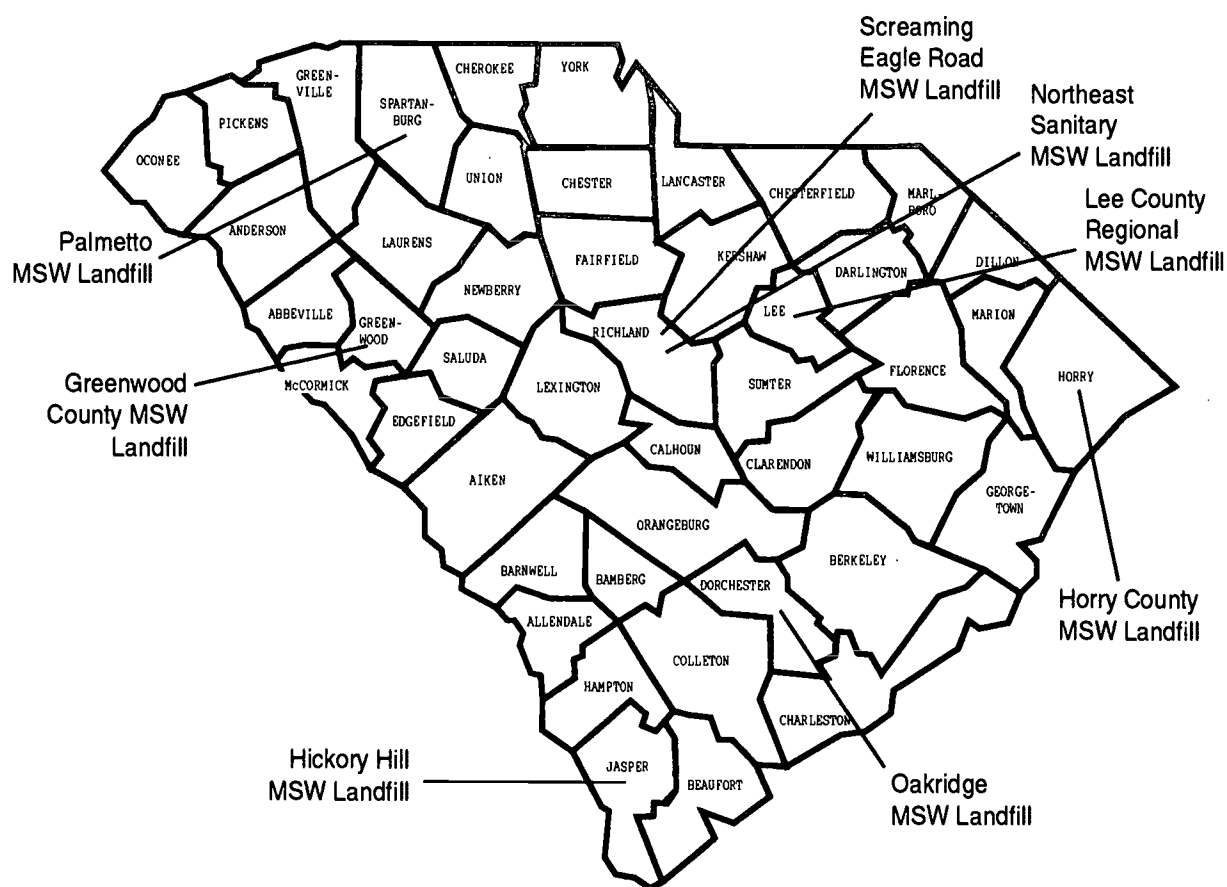
Public awareness of the importance of water and land-use preservation grew dramatically during the 1960s and 1970s.

In the 1970s the Resource Conservation and Recovery Act (RCRA) was passed. This was the

first comprehensive legislation that dealt with landfills.

Today, landfills must be designed and operated under strict environmental guidelines administered by the U.S. EPA. In South Carolina, the Department of Health and Environmental Control enforces federal and state standards, devises programs to manage state-specific solid waste management, and issues operating permits to new and existing solid waste management operations. The South Carolina Solid Waste Policy and Management Act, signed May 27, 1991, establishes the policy of the state regarding solid waste.

SOUTH CAROLINA MUNICIPAL SOLID WASTE LANDFILLS THAT ARE PERMITTED AND MEET THE RCRA SUBTITLE D STANDARDS.



A Closer Look At Incineration

To incinerate means to burn to ashes. The burning takes place in a combustion chamber called an incinerator. A benefit of waste incineration is that, when wastes are burned, the resulting ashes take up less space in our landfills.

Although waste combustion is listed in the U.S. EPA's Integrated Waste Management strategy *before* landfilling, incineration is a waste management method that sparks controversy among scientists and citizens.

In South Carolina, incineration is not listed as a priority over landfilling. However, as counties develop their waste management plans, incineration is an option.

The History of Incineration

The first municipal incinerator, called "the destructor", was designed and built in England in 1874. It seemed to be a simple, efficient, and sanitary way to dispose of garbage.

Burning garbage eliminated the need for transporting waste from cities, saved space in dumps, and destroyed many disease-causing microorganisms and viruses. The technology was soon imported to this country, and the first garbage incinerator in the United States was built on Governor's Island, New York in 1885. By the 1920's there were more than 300 incinerators in use in this country.

The first incinerators burned trash without worrying about what was coming out of their smokestacks.

As concern rose over the quality of our air and legislation was introduced to prevent further air pollution, the cost of pollution control equipment made it cheaper to landfill waste and use of incinerators declined.

From Waste To Waste-to-Energy

Technology was developed to absorb some of the heat from waste incineration. Heat was used to turn water to steam which could be used to generate electricity. By producing energy, facilities became more cost effective. Burning wastes to produce energy is known as resource recovery, and the facilities are referred to as **waste-to-energy** plants.

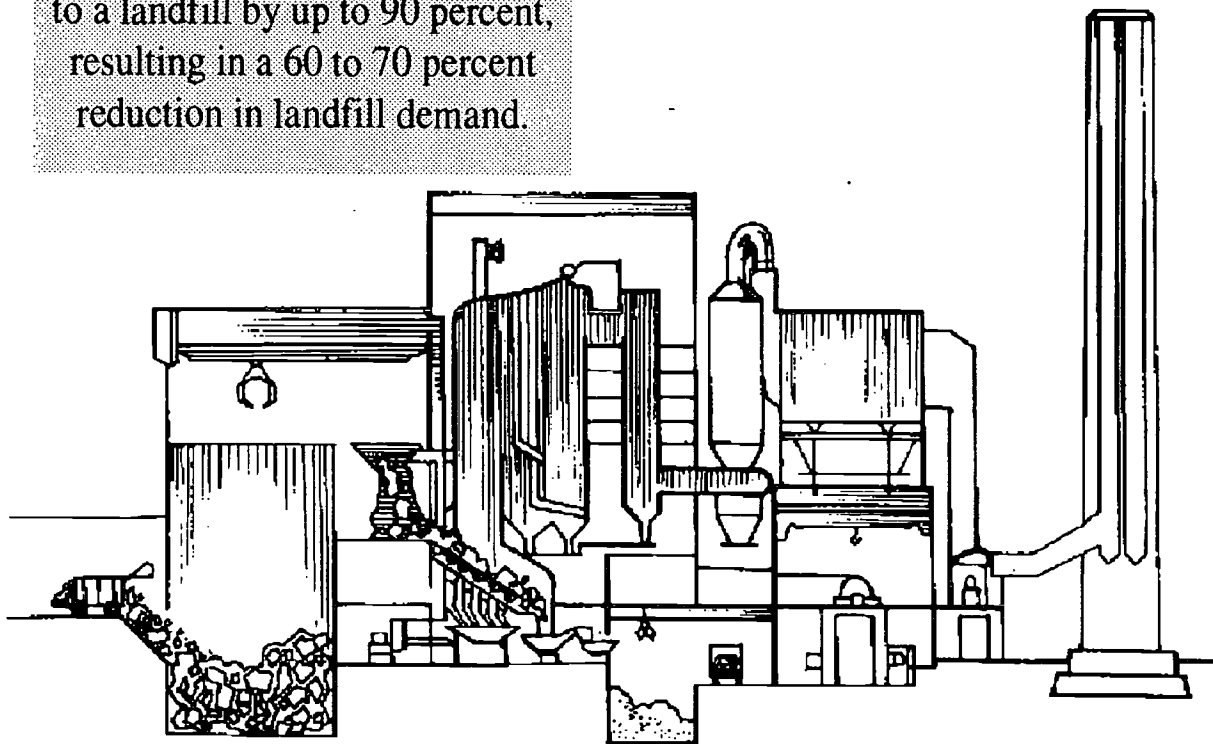
Burning wastes to produce energy lowered the temperature of incinerator exhaust to within temperatures where proven emission control equipment could operate effectively. Thus this technology made it possible to install pollution control equipment in incinerators. An incinerator's ability to generate electric power helped offset some of the high cost of installing this emission control equipment called **scrubbers**.

Today's waste-to-energy plants can reduce up to 90 percent of the volume of waste needing to be disposed and can be designed to process from 100 to over 3,000 tons of refuse daily. At the same time, these waste burning plants produce steam or electricity which can satisfy a portion of local energy needs.

There are currently more than 140 waste-to-energy plants operating in the United States. Of these, 64 are mass-burn facilities where mixed garbage burns in a single combustor and steam is generated which produces electricity; 49 are modular meaning they have two combustion chambers with a special chamber for destroying harmful gases, recover steam for energy, and are generally smaller than mass burn facilities; and 27 are refuse-derived fuel plants that burn materials that generate the most heat such as used oil.

South Carolina currently has two solid waste combustors permitted. They are in Charleston County and Hampton County. The state also has two hazardous waste incinerators, one in Roebuck and the other in Rock Hill.

Incinerating solid waste can reduce the volume of trash going to a landfill by up to 90 percent, resulting in a 60 to 70 percent reduction in landfill demand.



How Do Incinerators Work?

Incinerators burn waste to reduce its volume; that is, to make it smaller. Incinerators can burn unprocessed waste (mass burn) or processed waste (refuse-derived fuel). Incinerators can be equipped to generate energy by using the heat from burning garbage to turn water to steam, which is then either fed into a steam-loop (sometimes called a district heating system) or used to turn turbines installed at the incinerator plant to generate electricity.

Mass-burn facilities appear convenient from a solid waste management perspective. There is no pre-processing of waste, and no changes must be made in the way most municipalities collect their trash. When trucks enter a waste-to-energy facility, their loads are weighed, and the trash is delivered to a tipping platform. Front-end loaders and cranes are used to push the waste down a shoot (hopper), from where it is fed into the combustion chamber. The residual ash from the combustion chamber (bottom ash) and that collected by pollution control

equipment (fly ash) is deposited into large covered dumpsters which are hauled away to a lined, specially permitted, sanitary landfill.

Incinerators require a steady flow of waste and need to maintain a steady temperature in burning. Non-combustibles in the waste stream such as glass and metal inhibit efficient burning as do kitchen wastes, leaves and grass because of their high moisture content (30-75 percent water) and low Btu (or heat released during combustion) value. Increasing amounts of petroleum-based plastic, with a high Btu value, in the waste stream also affect burning. To maintain a consistent temperature, incinerator operators must regulate a changing solid waste composition, the amount of trash fed into the plant, how the system is started up and shut down, and other variables that change burning temperatures.

What Are Some Of The Benefits Of Incinerators?

Incinerating solid waste can reduce the volume of trash going to a landfill by up to 90 percent, resulting in a 60 to 70 percent reduction overall in landfill demand. By doing, this incineration helps conserve land and protect water sources from contamination.

Incineration also destroys potentially disease-causing organisms in solid waste and helps keep them out of landfills. Incineration also destroys a number of chemicals and toxic compounds, such as pesticides, that are a major source of contamination at existing landfills. Dioxins are both created and destroyed in the incinerator combustion process, and some data indicate that resulting dioxin levels may be reduced overall from that found in incoming solid waste.

What Are Some of the Problems of Incinerators?

In weighing the benefits of incineration against the drawbacks, communities must look at the costs of controlling and monitoring pollutants from air emissions, the disposal of incinerator ash, and the financing and siting of facilities.

Also, incinerators share many of the problems of any waste management facility (such as landfills and recycling centers), including truck traffic and associated noise and litter. However, since operations take place within an enclosed structure at an incinerator, problems such as litter, odors and insect and rodent infestation are better controlled than at a landfill.

The byproducts of incineration, — ash, gases, and heat — can be collected and reused to a large extent. And while incineration is a highly efficient method of waste disposal, there is some concern over the remaining byproducts.

Although modern incinerators use sophisticated air pollution control technology, emissions must be carefully monitored and controlled. The U.S. EPA

estimates that more than 95 - 99 percent of particulate and organic pollutants can be removed from air emissions if certain pollution prevention steps are followed.

Ash is a substantial byproduct of incinerated garbage. According to *The Garbage Primer from the League of Women Voters*, an incinerator that burns 1,000 tons of trash per day can generate between 200 and 250 tons of ash a day as a residue. The composition and toxicity of incinerator ash depends on the content of the waste burned and the efficiency of the combustion. Ash is disposed of in special landfills called ash monofills.

Incinerators are expensive to invest in, operate and maintain, making it most economical to build large plants so that costs-per-ton-of-waste accepted are lower. However, large sums of money must be borrowed to construct an incinerator, and whether the plant is running at half or full capacity, the agreed upon schedule of payments must be met. Therefore, although larger plants may be more economical, oversizing a plant can be very expensive and actually can create something of a “demand” for waste, something contrary to waste management goals. Facilities are perhaps best undersized but designed with space to add an additional incinerator unit should it be needed.

How Does Incinerator Pollution Control Equipment Work?

The Clean Air Act, passed in 1970, limits emission of seven major classes of pollutants: particulates, sulfur dioxide, carbon monoxide, ozone, hydrocarbons, nitrogen dioxide, and lead.

This legislation put an end to incinerators without pollution control devices, as well as routine uncontrolled burning at open dumps. Pollution control devices are now required on incinerators to remove particulates, acid gas, and toxic compounds created in burning solid waste. Any incinerator that operates in South Carolina will have to comply with strict air pollution control regulations for its exhaust.

Pollution control in a state-of-the-art incinerator consists of temperature controls, "dry" or "wet" "scrubbers," and "baghouses." To receive an operating permit in South Carolina, an incinerator must have all of these controls in place. Temperature controls must have efficient combustion between 1,500 to 1,800° F to eliminate most particulate matter. Second, exhaust gases are carefully "co-aired" or cooled to precipitate out any dangerous vaporizing metals, such as lead and mercury. "Scrubbers" then use reagents (like lime) to neutralize acid gases.

Finally a "baghouse," essentially a fine mesh filtering system which works something like a vacuum cleaner bag, strains out particulates (solid matter remaining including the precipitated metals) from the exhaust gases. Together these controls eliminate most, but not quite all, particulates and acid gases from incinerator emissions.

In South Carolina these emissions are continuously tested to see that all particulates and gases are within levels permitted by the U.S. EPA and South Carolina Department of Health and Environmental Control (DHEC).

What Happens To Incinerator Ash?

In most cases, both "bottom ash" from the combustion chamber and the generally more toxic "fly ash" collected by the "baghouse" are combined for disposal and sent to double-lined landfills. Ash is tested before transportation to check its potential for leaching metals in mixed solid waste landfills. Leachate is collected in pipes, located above the liners at the bottom of the landfill which empty into a holding tank the contents of which are then taken to a waste water treatment plant for final treatment.

What Is the Debate Over Incinerator Safety?

There is much public debate about the safety of incinerators concerning their emissions and disposal of their ash. Proponents of incineration maintain that the toxicity of emissions and ash are well within levels determined safe by state and federal regulators, and most often, in fact, are

substantially below levels that should be of remote concern. They also point out that incineration may actually reduce the amount and leachability of toxic substances that would otherwise be landfilled. Opponents of incineration maintain that some potentially dangerous emissions or leachables are not tested for or regulated, and many of those that are regulated, are permitted at levels of exposure that have not been proven safe or are, at least, open to question. They also note that incinerators concentrate toxic materials in their ash, compounding the problems of landfills and any accidents in handling the ash.

The incinerator safety debate is one of whether it is safe to proceed with incinerating waste on the basis of what we know. Proponents say that, based on what we know scientifically about the potential risks of incineration and landfilling its ash, there appears to be no significant public health threat. Opponents say that despite some studies, we know too little about the effects of long-term, low-level exposure to some of the byproducts of incineration and that, until we know more, we should not take a chance with public health. In the last analysis, this debate becomes social rather than technical in nature: a question of faith in technology and the limits of human ability to intervene safely in the environment. Whether incinerators operate in a given community or not ultimately will be determined by political and economic factors.

What Is The Future Of Incineration?

Although influential groups such as banks and construction companies may strongly support constructing incinerators, once constructed the uncertainties of future government regulation and vocal opposition as well as legal challenges to any incinerator have the potential to increase the cost to its investors and users. Regulation may affect both the ability of a plant to operate at full capacity (and therefore, economically) and may increase the cost of disposing of its ash (for example, if ash were to be classified as hazardous waste, as is sought by some). Although revenues from power generation

may in part offset a fraction of incinerator costs, these revenues have proved quite variable as utilities have negotiated and public service boards determined the rate that an incinerator receives for its power. Like other waste management options, incinerators will be successfully operated only to the extent that they avoid the costs of alternate disposal means and associated environmental problems.

Finally, incinerators can be only as safe as the waste that is fed into them ... wastes that society produces. Whatever other safety problems there may be, incinerators and their ash will be safest if nothing toxic (for example, batteries), nothing recyclable (metals, plastics, glass, paper) and nothing that can be composted (food and yard waste) goes into them.

An incinerator burning only mixed waste without toxics, recyclables, or compostable materials, will minimize any potential burning, pollution control and mechanical problems of incinerator technology.

Sources: *Wastewise*; Pollack, 1987; Natural Resources Defense Council, March 1988; *South Carolina Solid Waste Management Plan 1992 and 1993*; 1993 and 1994 *Information Please Environmental Almanac*

More on incineration ...

Japan incinerates about 34 percent of its waste, compared to 10 to 14 percent in the United States.

Japan has built over 1,900 incinerators in the last 25 years.

According to the National Solid Wastes Management Association, creating energy from garbage is a much cleaner process than using traditional fuels such as coal.

By the end of 1991, there were 140 energy-recovery or waste-to-energy facilities operating in the United States with a combined capacity of 94,000 tons per day.

It is estimated that if all the energy-recovery facilities currently planned come on line, 24 percent of the nation's municipal solid waste will be incinerated in the year 2000.

Plastics have the highest stored energy value of all materials commonly found in the waste stream. HDPE plastic generates 18,700 Btu per pound compared to 20,900 Btu per pound generated by fuel oil and 9,600 Btu generated by Wyoming Coal.

Among the states with the highest capacity for burning trash are Massachusetts (9,700 tons per day) and Pennsylvania (7,000 tons per day).

If the energy could be captured from all the wood and paper that Americans throw away each year, 40 million homes could be heated for 25 years.

Building new waste combustion facilities is expensive ... around \$100 million for an averaged sized plant with the capacity of 1,000 tons per day.

The Foster Wheeler waste-to-energy plant in Charleston County receives approximately 225,000 tons of solid waste annually. Electricity generated on site is sold to Carolina Power & Light.

Chambers Medical Technologies owns and operates a waste-to-energy incinerator in Hampton County that receives about 68,000 tons of solid waste annually. The facility has a heat recovery system that produces steam. The plant handles most of the solid waste generated in Bamberg, Colleton and Hampton counties and other wastes generated by industries including medical wastes.

A Closer Look at Air Pollution

Air pollution is dangerous to the health of humans and other things living on Earth. Although it is often invisible, air pollution knows no boundaries. It creates smog and acid rain, causes cancer or other serious health effects, diminishes the protective ozone layer in the upper atmosphere, and contributes to the potential for world climate change.

Smog and other types of air pollution can lead to or aggravate respiratory, heart, and other health problems. It can be particularly harmful to people with existing lung or heart disease, the elderly, and the very young.

According to the U.S. Environmental Protection Agency, **six of every ten Americans live in areas that fail to meet one or more federal air quality standards during some portion of the year.** However, not everyone who lives in such areas will have health problems. Many factors play a significant role in determining whether or not someone will experience pollution-related health problems. These factors include level, extent, and duration of exposure, as well as the age and susceptibility of individuals exposed to air pollution. Since polluted air can move from one area or region to another, it has the potential to affect all of us.

Acid rain — caused by sulfur dioxide and nitrogen oxides combining with moisture in the air — limits the ability of lakes to support aquatic life. It may also damage trees and plants, and erodes building surfaces and national monuments. Pollutants in the air can also reduce visibility, obscuring the majestic vistas in national parks such as the Grand Canyon and the Shenandoah Valley.

Other air pollutants — known as “air toxics” — are known or suspected to cause cancer or other serious health problems, such as damage to respiratory or nervous systems. Air toxics include metals, particles, and certain vapors from fuels and other sources.

Some chemicals used in refrigerators and air conditioners last a long time if released into the air, rising to the upper atmosphere where they destroy the

protective ozone layer. These and other air pollutants (like methane and carbon dioxide) also contribute to the suspected accelerated warming of the earth, known as the “greenhouse effect.”

Air pollution comes from many places. Some, like industrial smokestacks, chemical plants, automobiles, trucks, and buses, are well known. Others, like gas stations, dry-cleaners, outboard motors, lawn, garden, farm, and construction equipment engines; certain paints; and various household products, are not so obvious.

Here are the major pollutants, their sources, and their potential effects.

Ozone: A colorless gas that is the major constituent of photochemical smog at the earth’s surface. In the upper atmosphere (stratosphere), however, ozone is beneficial, protecting us from the sun’s harmful rays.

Ozone is formed in the lower atmosphere as a result of chemical reactions between oxygen, volatile organic compounds (VOCs) and nitrogen oxides in the presence of sunlight, especially during hot weather. Smog — formed by the reaction of these chemicals with sunlight — is called photochemical smog. Sources of these harmful pollutants include vehicles, factories, landfills, industrial solvents, and numerous small sources such as gas stations, farm and lawn equipment, etc.

Ozone causes significant health and environmental problems here at the earth’s surface. It can irritate the respiratory tract, produce impaired lung function such as inability to take a deep breath, and cause throat irritation, chest pain, coughing, lung inflammation, and possible susceptibility to lung infection. Components of smog may aggravate existing respiratory conditions such as asthma. It can also reduce yield of agricultural crops and injure forests and other vegetation. Ozone is the most injurious pollutant to plant life.

Carbon Monoxide: Odorless and colorless gas found in the exhaust of motor vehicles and other kinds of internal combustion engines where fossil fuels are not completely consumed.

Automobiles, buses, trucks, small engines, and some industrial processes produce carbon monoxide. High concentrations can be found in confined spaces like parking garages, poorly ventilated tunnels, or along roadsides during periods of heavy traffic.

Carbon monoxide reduces the ability of blood to deliver oxygen to vital tissues, affecting primarily the cardiovascular and nervous systems. Lower concentrations have been shown to affect individuals with heart disease (for example: angina) and to decrease maximal exercise performance in young, healthy people. Higher concentrations can cause symptoms such as dizziness, headaches, and fatigue. In enclosed spaces, high concentrations can cause death.

Nitrogen Dioxide: Light brown gas at lower concentrations; in higher concentrations it becomes an significant component of unpleasant-looking brown urban haze. It is the result of burning fuels in utility plants, industrial boilers, cars, and trucks.

One of the major pollutants that causes smog and acid rain, nitrogen dioxide can harm humans and vegetation when concentrations are sufficiently high. In children, it may cause increased respiratory illness such as chest colds and coughing with phlegm. For asthmatics, it can cause increased breathing difficulty.

Particulate Matter: Solid matter or liquid droplets from smoke, dust, fly ash, and condensing vapors that can be suspended in the air for long periods of time. Particulate matter comes from industrial processes, smelters, automobiles, burning industrial fuels, woodsmoke, dust from paved and unpaved roads, construction, and agricultural ground breaking.

These microscopic particles can affect breathing and the respiratory system, causing increased respiratory disease and lung damage and possibly premature death.

Children, the elderly, and people suffering from heart or lung disease (such as asthma) are especially at risk.

Particulate matter also damages paint, soils clothing, and reduces visibility.

Sulfur Dioxide: Colorless gas, odorless at low concentrations but pungent at very high concentrations. It is emitted largely from industrial, institutional, utility, and apartment-house furnaces and boilers, as well as petroleum refineries, smelters, paper mills, and chemical plants.

Sulfur dioxide is one of the major pollutants that causes smog. At high concentrations, it can also affect human health, especially among asthmatics who are particularly sensitive to respiratory tract problems and breathing difficulties that sulfur dioxide can induce.

Sulfur dioxide can also harm vegetation and metals. The pollutants it produces can impair visibility and acidify lakes and streams.

Lead: Lead and lead compounds can adversely affect human health through either ingestion of lead-contaminated soil, dust, paint, etc., or direct inhalation. This is particularly a risk for young children, whose normal hand-to-mouth activities can result in greater ingestion of lead-contaminated soils and dusts. Lead comes from transportation sources using fuels containing lead, coal combustion, smelters, car battery/plants, and combustion of garbage containing lead products. As of December 31, 1995, South Carolina does not allow lead in any gasoline sold.

Elevated lead levels can adversely affect mental development and performance, kidney function, and blood chemistry. Young children are particularly at risk due to their greater chance of ingesting lead and the increased sensitivity of young tissues and organs to lead.

Toxic Air Pollutants: Pollutants such as arsenic, asbestos, and benzene. Toxic air pollutants often come from chemical plants, industrial processes, motor vehicle emissions and fuels, and building materials.

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They are known or are suspected to cause cancer, respiratory problems, birth defects, and reproductive and other serious health effects. Some can cause death or serious injury if accidentally released in large amounts.

Stratospheric Ozone Depleters: Chemicals such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform that are used in refrigerants and other industrial processes. These chemicals last a long time in the air, rising to the upper atmosphere where they destroy the protective ozone layer that screens out harmful ultraviolet (UV) radiation before it reaches the earth's surface.

These ozone depleters result from industrial and household refrigeration chemicals, cooling and cleaning processes, car and home air conditioners, some fire extinguishers, and plastic foam products.

Increased exposure to UV radiation could potentially cause an increase in skin cancer, increased cataract cases, suppression of the human immune response system, and environmental damage.

Greenhouse Gases: Gases that build up in the atmosphere that may induce global climate change — or the “greenhouse effect.” They include carbon dioxide and methane.

The main man-made source of carbon dioxide emissions is fossil fuel combustion for energy-use and transportation. Methane comes from landfills, cud-chewing livestock, coal mines, and rice paddies. Nitrous oxide results from industrial processes such as nylon fabrication.

The extent of the effects of climate change on human health and the environment is still uncertain, but could include increased global temperature, increased severity and frequency of storms and other “weather extremes,” melting of the polar ice cap, and sea-level rise.

What can we do at home and at school to prevent air pollution?

- **Conserve electricity.** Generating electricity can be a major source of air pollution. New home- and office-oriented technology can help. At home or work you can save electricity by using energy-efficient lighting wherever possible. Make sure that lights and appliances are turned off when not in use. In addition, you should raise the temperature level on your air conditioner a few degrees in summer, and turn down your heat a few degrees in winter.

Purchasing energy-efficient appliances will also aid in conserving energy use. Conserving electricity reduces air pollution caused by power plants.

- **Buy fuel-efficient motorized equipment.** If you are buying a power mower or other motorized garden tools, construction or farm equipment, or outboard motors, seek out those that are designed to minimize emissions and reduce spillage when being refueled.

- **Avoid spilling gas.** Take special care to avoid spills and the release of fumes into the air when refueling gasoline-powered lawn, garden, farm and construction equipment, and boats.

- **Properly dispose of household paints, solvents, and pesticides.** Do not pour these chemicals down the drain, into the ground, or put them into the garbage. Call S.C.DHEC at 1 800 So USE IT for information on proper disposal of these products.

- **Seal containers tightly.** Make sure that containers of household cleaners, workshop chemicals and solvents, and garden chemicals are tightly sealed to prevent volatile chemicals from evaporating into the air. Don't leave containers standing open when not in use.

- **Reduce waste.** When you make purchases, consider using products that are durable, reusable, or that use less packaging. Repair broken items rather than buying new ones. Recycle and compost potential wastes before they become part of the waste stream. Such actions help reduce the pollutants that might reach the air during the

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manufacturing process or during the collection and processing of wastes for incineration or landfill disposal.

- **Use wood stoves and fireplaces wisely and sparingly.** If you have a wood stove, learn how to burn cleanly and more efficiently. Remember to burn dry, well-seasoned wood, and build efficient fires that burn hot and clean. Check your stack, clean your chimney, and inspect your catalyst annually. A well maintained and operated stove produces less pollution and is better for the environment.

- **Properly dispose of refrigeration and air conditioning equipment.** The U.S. Clean Air Act prohibits the release into the atmosphere of refrigerants from automobiles and home appliances during the disposal of this equipment. Contact your local government or trash pickup service to find out what procedures there are in your area to ensure the safe

disposal of cars and home appliances. In some areas, municipalities arrange for periodic pickups of home appliances that contain refrigerant. In others, it is required that homeowners have the refrigerant removed by a qualified service technician before the appliance can be picked up. If you have any questions, contact S.C.DHEC at 1-800-SO-USE-IT for more information.

- **Recycle refrigerant.** As of July 1, 1992, individuals are prohibited from knowingly venting refrigerant into the atmosphere while maintaining, servicing, repairing, or disposing of air conditioning or refrigeration equipment. Make sure the technician who services, repairs, or maintains your refrigerator or air conditioner has recovery equipment to capture any refrigerant that may be released. This refrigerant can later be recycled. Also, when possible, don't just refill leaky air conditioning or refrigeration systems — repair them.

A Closer Look at Water

There are nine planets in space circling the sun. These nine planets make up our solar system. Each planet has unique qualities because of its orbital position as it travels around the sun. As far as scientists are aware, only one of these nine planets has ever sustained what we know as life.

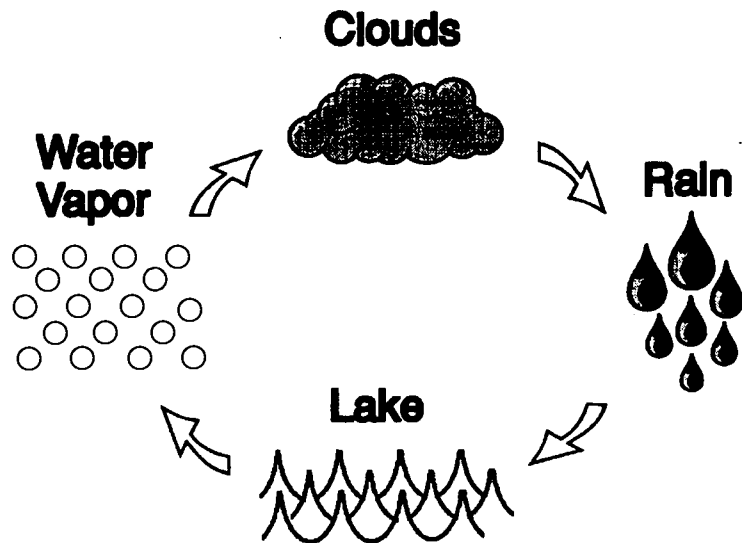
From out in space the planet Mars appears red, Venus is shrouded in dense clouds, and Earth is a distinct blue swirled with white cloud bands.

The “blueness” tells us something important about the characteristics of planet Earth. This planet is the *water* planet.

The fact that this is the only planet that sustains life, also tells scientists something important about water and life. Water is crucially important to life on Earth. Human bodies are over two-thirds water. Many animals such as the jellyfish contain an even higher amount of water. Humans can go for many days without food, but only a few without water. No organism survives without water in some form.

The compound water is a simple one. Two hydrogens and one oxygen combine to make water. Water is also an interesting molecule. It is one of only a few compounds which can exist in solid, liquid, and gaseous states of matter under normal, seasonal, climatic conditions. Water is also a unique compound because as it changes from a cold liquid to a solid, it becomes *less* dense. Ice cubes and icebergs float! Think about what Earth would be like if lakes and oceans froze solid all the way to the bottom over the winter. Water is also a universal solvent, easily dissolving many of the substances it comes in contact with. As it flows over the Earth’s surface, water is constantly wearing away and changing the surface of the planet.

If Earth’s water was quickly consumed by its life forms and once used up was forever gone from the planet, Earth would soon look very much like some



of the other planets in our solar system. However, on planet Earth, water is constantly moved in a large circular pattern or cycle so that it is never used up.

The sun heats surface water causing water to change from a liquid state to its gaseous state. The water vapor rises above the Earth until it reaches a height where it becomes cooled and clouds of water droplets are formed. As the clouds build, rain and other forms of precipitation return the water back to the Earth’s surface where it runs off into lakes, streams, and the ocean or soaks down to become ground water. This great cycling of water does not mean that there is an endless supply. Because of water’s capacity to dissolve, it can quickly become dirty and unfit for life forms to use.

The entire water cycle can be observed in South Carolina on a hot summer day. In the morning the sky is a clear blue. As the day goes on, the sun heats the Earth’s surface and water is evaporated from rivers, lakes, and the ocean. Trees also give off water in a process called *transpiration*. This water vapor rises into the atmosphere. As the water vapor moves higher in the atmosphere, it reaches an area where cooler temperatures cause condensation to occur. The droplets formed during condensation gradually come together as puffy cumulus clouds. As the afternoon passes, the hot sun continues to heat surface water

creating more water vapor which then rises and condenses into more clouds above the earth. By mid afternoon, the sky is no longer a clear blue, but is filled with clouds. By late afternoon, these clouds may join together and build into dark rain clouds. A short thunderstorm later, the water returns to the Earth's surface as a summer rain shower.

From space, the blue oceans are the dominate feature of Earth. It would seem that there is more than enough water for every living thing. However, most organisms need water in a much purer form than that found in the oceans. Most animals and plants need FRESH water. Parts of the Earth are rich in fresh water streams, rivers, and lakes. South Carolina has

many surface water bodies. The Savannah, Broad, and Catawba Rivers drain water from the mountains into the Atlantic Ocean. South Carolina's landscape is dotted with many large natural and man-made lakes.

The Earth also contains another source of fresh water located down in the ground. These stores of fresh water, known as groundwater, can be accessed by wells to supply drinking water to a large portion of the human population.

In South Carolina, 60 percent of the population gets its drinking water from groundwater. The groundwater is constantly replenished by precipitation that soaks deep into the ground. The groundwater flows very slowly towards the oceans and can be easily contaminated by

pollutants that seep down from spills on the surface. Once contaminated, groundwater is very difficult to clean.

The rapid growth of Savannah, Georgia has created a high demand on its underlying groundwater. When groundwater is removed from its aquifer faster than it can be recharged from above, several problems can occur. Not only is there less water at Savannah but now, at nearby Hilton Head Island, so much groundwater has been removed to serve Savannah's needs that salt water from the ocean is moving in to

The Hydrologic Cycle



As the water moves through the hydrologic cycle, it changes the appearance of Earth via the friction of liquid water moving over rock and soils. Mountains are worn away and lakes are filled with sediment as water continues its passage from the atmosphere to the oceans and back. Some of the shape of South Carolina is due to water flowing from the southern Appalachian Mountains toward the Atlantic Ocean.

Water that soaks down below the surface may not return to the cycle as quickly and may remain underground for many years. As the water moves through the hydrologic cycle, it changes the appearance of the planet Earth via the friction of liquid water moving over rock and soils. Mountains are worn away and lakes are filled with sediment as water continues its passage from the atmosphere to the oceans and back. Some of the shape of South Carolina is due to water flowing from the southern Appalachian Mountains toward the Atlantic Ocean.

fill the spaces where groundwater was stored. As a result, many wells on Hilton Head Island now contain water that is slightly salty.

Since the earliest times, humans have used water from lakes and rivers to drink, cook, and wash. Flowing water has also been used to get rid of wastes. In dry areas, shallow wells have been dug to supply fresh water. As more and more humans used water for a multitude of purposes, disease organisms also adapted to use this route to pass from human to human. Cholera and typhoid killed many and made large numbers of people very ill. In more modern times, industry used water for various purposes, often returning it back to its source in a polluted state. Others used water to dump wastes, using the natural flow to carry these “bad things” away from their homes. Unfortunately, someone else lived downstream and then had no clean water to use.

The ancient Chinese knew that when consumed, some water could make humans sick. Early writings indicate that boiling water made it safer to drink. The Greeks knew to filter water through cloth to remove impurities. In modern times, we know that water directly from its source is often not suitable to drink. This water must be cleaned and purified using much the same methods as ancient cultures.

Today, all drinking water from a public water source (not a private homeowner well) is carefully treated and monitored to ensure that the safest product flows from your tap. Source water passes through a Water Treatment Plant where the water is filtered and cleaned of microorganisms using a variety of disinfectants. It is then sent through underground pipes directly into the home. The amount of water each home uses is metered and a water bill is derived. People in advanced cultures no longer need to carry buckets of water daily from a community well.

Since outbreaks of waterborne diseases are fairly rare in civilized parts of the world, people tend to take clean drinking water for granted. The water bill comes each month and people often wonder, “Why

do I have to pay for such an abundant resource?” Providing clean, safe water to homes, work and school is a big challenge. Treatment plants must constantly upgrade their facilities to the latest technologies as source water becomes increasingly polluted. The more polluted the source water is, the more processes it must go through at the Water Treatment Plant to be safe for human consumption. The many challenges to providing safe drinking water to the public require a constant vigilance by federal, state, local agencies, and the water treatment industry.

Lastly, if the blue planet Earth’s abundant water is constantly cycled over and over, then there would seem to be no need to practice conservation measures. Earth contains about the same amount of water as it always has. But once this water becomes contaminated, it becomes less useable. Groundwater that is poisoned by gasoline leaking from underground storage tanks is not fit to drink. Lake water that is contaminated by runoff full of fertilizers and pesticides from lawns and gardens also is less useable. When too much water is pumped from wells, the underlying aquifer is emptied. In coastal areas the aquifer’s fresh water stores can become mixed with salt water. And water that is uselessly poured down the drain while washing dishes, brushing teeth or taking a shower eventually makes its way into the oceans where it becomes salt water. As the population of humans on the planet and their ensuing demand for water grows, while more and more water is polluted and wasted, some form of water conservation will be necessary. Hopefully, people will be wise enough to protect this precious resource while they still can.

A Closer Look At Energy

excerpts from the *Energy FactBook*, a resource for South Carolina produced by the State Energy Office

WHAT IS ENERGY?

Energy is what makes things work. When we flip on a light switch, we use energy. We use energy riding a bus to school. Listening to a favorite song on a CD player uses energy. Try to imagine a world without energy. There would be no TV, no computers and no cars. Energy is what makes our lives comfortable and prosperous.

WHERE DOES ENERGY COME FROM?

A major source of energy is the sun. The sun's light and heat are both forms of energy. Plants use the sun's energy to grow. When we eat plants, we take in their energy. This gives us the energy to think and learn.

The wind and sea are energy sources. So too are oil, coal, natural gas and wood.

ENERGY'S ROLE IN HISTORY

Because energy is basic to our lives, it is at the very heart of civilization. Prehistoric people learned to use fire's heat energy. They used it to take away the night's chill, to cook food and to fashion tools.

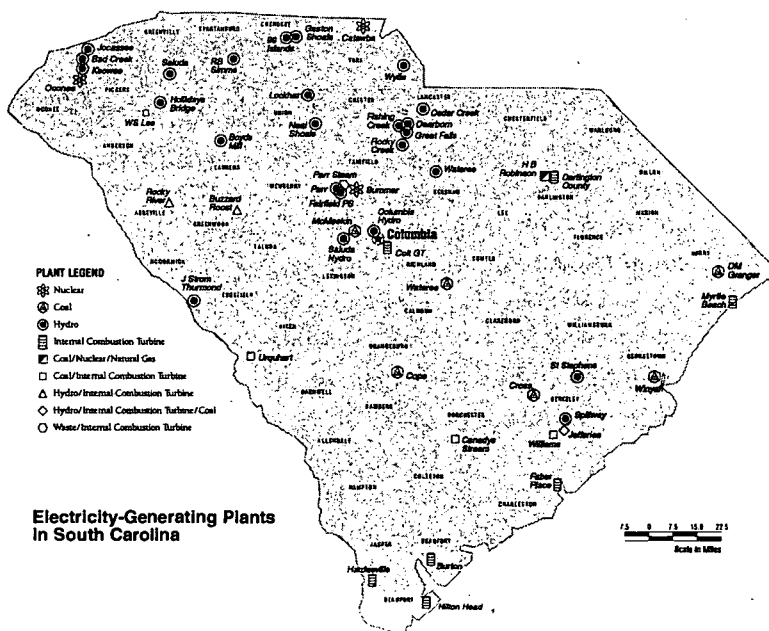
The ancient Egyptians discovered there was energy in wind. They used it to sail their ships. By the first century B.C., people learned to use the energy power of water. The waterwheel harnessed the energy of moving water. Water power was stronger than the muscle power of both people and animals combined.

The principle behind the waterwheel was also applied to the wind. Windmills popped up in the lowlands of Europe. Using only the wind for power, windmills ground grains into flour. In areas

far from the seas, wind power became an important energy resource. By the 1800's, civilization searched for more energy resources. People, work animals (such as horses and oxen) and wood were no longer enough. While water and wind power continued to fill many energy needs, they were unreliable.

The answer to this quest came in the form of James Watt's invention of the steam engine. Steam took industry indoors. Workers left their rural homes for work in big city factories. The Industrial Revolution pushed civilization "full steam" ahead.

Other energy inventions followed. One exciting idea seemed to spark another. Work by physicists in Europe and experiments by Thomas Edison in New Jersey led to the invention of the light bulb in 1879. By 1882, New York's Pearl Street generator was routinely sending electricity into homes.



OUR CHANGING ENERGY NEEDS

Inventions and industrialization also changed our energy needs. In Colonial times, wood was the chief fuel used in the U.S. By the 1850's, wood was

still filling 90% of our energy requirements. Coal was also becoming an important fuel, since it powered the steam engines that ran factories.

All of this changed in 1859 with the invention of the internal combustion engine. The gasoline-driven internal combustion engine became the foundation for the "horseless carriage." Cars transformed American society forever. Their huge popularity made gasoline the driving energy force in our economy.

For the first two-thirds of the 20th century, America was the undisputed technological king of the world. Our prospering economy, even after two World Wars, was built on our many energy resources. We consumed petroleum, natural gas, coal, and wood with confidence that these resources would not run out. Nuclear energy also became an important resource. Americans were unmatched in their ability to use energy of all types. By 1970, the 210 million citizens of the U.S. used more energy for air conditioning than the 800 million citizens of China used to fill all of their energy needs!

THE OIL CRISIS OF 1973

Then came the Oil Crisis of 1973. Politics suddenly controlled energy resources. Because the U.S. politically supported Israel, the oil-rich Arab countries stopped selling us oil. Everyone felt the impact of the oil shortage. Airlines cut back on flights. Vacations were canceled. Administrators thought about shortening the school year. Workers lost jobs. For the first time, people stopped taking energy for granted.

OUR ENERGY FUTURE

Fortunately, that Crisis ended in 1974. Perhaps even more fortunately, we learned important lessons. We now know our energy supplies are not limitless. Petroleum, in particular, may not always be plentiful and inexpensive.

In response, we have developed technologies that make better use of our resources. Appliances and homes have become more energy efficient. Scientists have also looked to untapped resources as alternative energy sources, like the use of waste products for fuels.

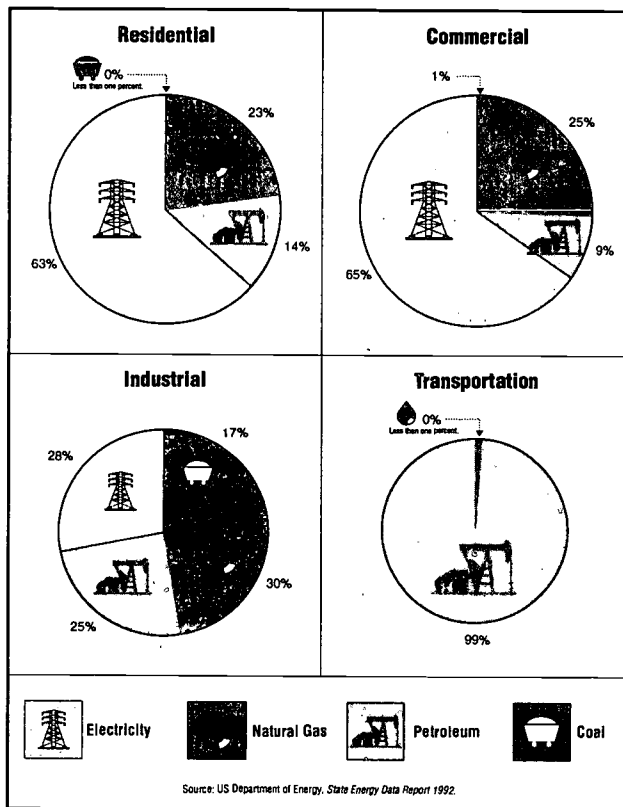
The Oil Crisis taught us to rethink the way we use energy. While energy use is still considered a sign of progress, energy waste

is now regarded as both shortsighted and thoughtless. Through conservation, we can lessen our dependence on foreign suppliers of energy, and prolong the life of those resources we have. Energy is something we must think about today and plan for tomorrow. It concerns us all.

ENERGY USE

Energy analysts commonly think about energy use in terms of groups or sectors of the economy – the residential, commercial, industrial and transportation sectors.

The **residential sector** refers to private home usage of energy. "Homes" include single and attached family houses and townhouses, apartments, farmhouses and mobile homes. In this sector, people use energy for heating and cooling homes, and running appliances.



Schools, hospitals, hotels and motels, movie theaters, and offices make up the **commercial sector**. Here, people use energy for heating and cooling as well as running business equipment such as computers and cash registers.

Manufacturers, miners, farmers, foresters and fisherman together form the **industrial sector**. Their energy needs are usually large, but can be quite small. They center on operating the machinery that runs our nation's factories and mills.

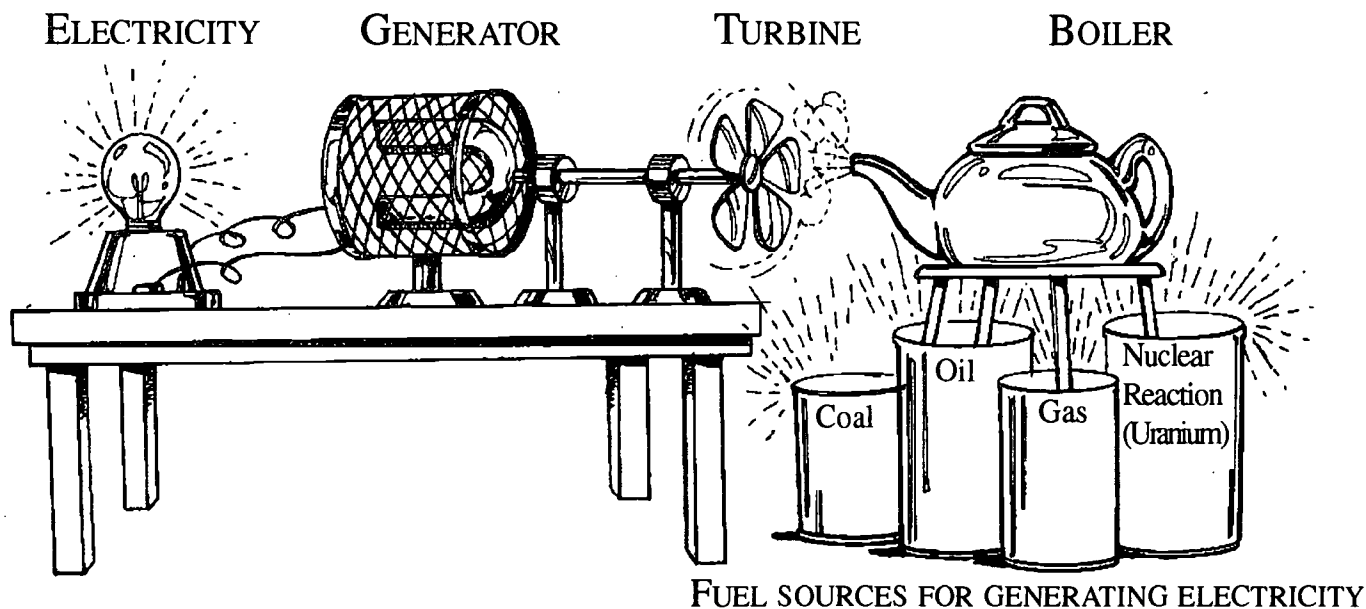
The **transportation sector** includes the cars, trucks, buses and motorcycles that run on our nation's highways. This sector also includes ships, trains, airplanes and helicopters. The energy needs for this sector are almost entirely for operating fuel.

The transportation sector is the second largest user of energy. Being primarily a rural state, this is not surprising. We are, by necessity, a state of drivers. It takes nearly two billion gallons of gasoline a year to keep South Carolinians on the move!

We use less energy in our homes. Twenty percent of the energy used in South Carolina serves to heat and cool residences and run appliances.

The commercial sector uses the least amount of energy. While this is true of most of the 50 states, in South Carolina the commercial sector uses proportionately even less. Only 13% of the state's energy is used by businesses, schools and hospitals.

Producing Electricity



SOUTH CAROLINA'S ENERGY SITUATION

South Carolina is a growing state. As our economy has developed, so too have our energy needs. While we use energy in every sector of the economy, industry uses the most. It takes large supplies of energy to run the mills, factories and farms that make our state prosper. In 1991, industry accounted for 40% of the state's energy use.

SOUTH CAROLINA'S CURRENT ENERGY PICTURE

South Carolina does not have many natural energy resources of its own. The gasoline and other fossil fuels that make our economy grow must be imported from other states and countries.

While we can't do anything about our lack of natural resources, we can do something to make us less dependent on expensive, imported fuels. With this in mind, state officials and citizens alike are actively seeking ways to improve our energy situation.

Through science and conservation, we are now using proportionally less fossil fuels. In 1990, over one-third of the state's energy needs were met by energy resources other than fossil fuels.

GENERATING ELECTRICITY

Today, most of the electricity we use is produced by power plants. The most common method uses steam. Coal, gas, oil or nuclear fuel are used to produce heat to make steam. In South Carolina, two-thirds of the electricity generated comes from nuclear power plants. In nuclear power plants the nuclear reaction produces the heat that is used to create steam.

Steam is piped to the turbine. The turbine's shaft is connected to a huge magnet in the generator. As steam turns the turbine, the magnet spins inside a coil of wire. This spinning action creates a force which causes the electrons on the metal wires to flow. Thus electrical current is produced.

From here, the electricity flows to the power plant transformer where it is "stepped up." After leaving the power plant, the electricity flows to substations of local utility companies. Here, the voltage is "stepped down" to a usable level. Electricity then flows through transmission lines from the substations to customers in the residential, industrial, and commercial sectors.

WATER POWER

Water power can also be used to generate electricity instead of steam, moving water is used to turn the turbine. To do this, water in great force is needed. This is why water-driven plants are located near rivers or lake dams.

Hydroelectric plants have been in existence since before the turn of the century. In 1900, 57% of the

electricity produced in this country came from water power. Today, hydroelectric power accounts for less than 4% of the electricity generated in South Carolina. This is mostly due to the fact lakes and rivers are currently being used to their full capacity.

HOW ELECTRICITY IS SOLD

In most cases, South Carolina's electricity is generated by power plants owned by the utilities. The utilities then sell the electricity to their customers. The electricity flows to a home or building through a distribution line and enters the facility at the meter point.

Meters measure the amount of electricity used in kilowatt-hours. One kilowatt-hour is about the amount of energy needed to run an iron for one hour.

Utilities need to anticipate consumers' demand for electricity. During hot summer days, everyone wants the air conditioner on full blast. Were the electric companies not prepared for this, there would be constant power shortages or brownouts.

Anticipating demand is important because electricity cannot be stored. To meet peak needs, utilities must generate all of the electricity they can or shift demand to off-peak times or incorporate energy saving measures. Sometimes they even have to purchase electricity from other utilities.

Glossary

aerate - To expose to the circulation of air, as in aerating a compost pile.

aerobic - Able to live and grow in the presence of free oxygen; aerobic bacterial decomposition results in the conversion of organic wastes to compost.

acid anhydrides - Oxides produced by burning nonmetals that, when combined with water, form acids. As gases, acid anhydrides may dissolve in rain to form acid rain.

acid rain - Caused by emissions from the burning of fossil fuels. When fuels such as coal, oil and natural gas are burned, many substances are emitted into the air. Sulfur dioxide and nitrogen compounds which contribute to air pollution travel through the air and react with each other in sunlight to form secondary pollutants such as sulfuric acid and nitric acid. When these acids fall to earth with rain, it is called acid rain.

air borne - Carried by or through the air.

air pollution - There are five primary air pollutants: carbon monoxide, hydrocarbons, nitrogen compounds, particulate matter, and sulfur dioxide.

anaerobic - Able to live and grow only in the absence of free oxygen; anaerobic decomposition of organic wastes by bacteria results in the production and release of methane gas.

altitude - The height of something measured in relation to a reference level, such as above the Earth's surface.

aluminum - A light, strong, silver-colored metal made mostly of bauxite ore. One of the most common materials accepted for recycling.

amber glass - A term used by the glass industry to refer to brown glass.

aquifer - An underground geologic formation in which the cracks in rock, sand, soil, or gravel are filled with water.

ash monofill - A specially constructed landfill to be used only for disposing ash from waste-to-energy plants.

atmosphere - The gaseous envelope surrounding the Earth.

baler - A machine that compacts waste materials, usually into rectangular bales. Balers often are used on newspaper, plastics and corrugated cardboard.

base cup - The high density polyethylene (HDPE) plastic base found on plastic soft drink bottles made of polyethylene terephthalate (PET).

bimetal - Made of two different metals. Examples include beverage cans steel bodies and aluminum lids.

bioaccumulation - Concentration of chemicals in the fatty tissues of living organisms, which may move up the food chain over time.

biodegradable - Capable of being broken down by microorganisms into simple, stable compounds such as carbon dioxide and water.

biodiversity - The vast diversity of plants and animals on earth.

bottle bill - A law in some states requiring deposits on beverage containers. South Carolina does not have a bottle bill.

bottom ash - The incineration process produces this ash which must be landfilled.

broadsheet - A term for 18th century newspapers.

broadside - A single sheet of music.

Btu - British Thermal Unit, or a unit of heat required to raise the temperature of one pound of water one degree Fahrenheit (For example, it takes 70 Btus to heat a cup of water from room temperature (72°F) to boiling).

Bureau of Drinking Water Protection - The component of S.C. Department of Health and Environmental Control charged with permitting and assisting public drinking water facilities, monitoring public drinking water, and educating the public about safe drinking water.

buy-back center - A place to sell recyclable materials.

CERCLA - An acronym for the Comprehensive Environmental Response, Liability and Compensation Act, or Superfund.

CFCs - Chlorofluorocarbons, any of various gaseous compounds of carbon, hydrogen, chlorine, and fluorine. If CFCs and their relatives are released into the air, they rise to the stratosphere. In the stratosphere, CFCs take part in chemical reactions which result in reduction of the stratospheric ozone layer, which protects the Earth's surface from harmful effects of radiation from the sun.

carbon dioxide - A common gas, CO₂ formed by respiration, combustion, and decomposition; comprises 0.03 percent of air.

carcinogen - A substance that can cause cancer.

cardboard - A kind of paper that is thicker, heavier and more rigid than other papers. It is known as paperboard within the paper industry and includes corrugated boxes and boxboard (such as cereal boxes).

caution - In labeling household hazardous waste, caution means be careful. The product should be used with care.

cell - An area in a landfill where solid waste is disposed of each day.

Center for Waste Minimization - A service offered by the South Carolina Department of Health and Environmental Control to help industries and businesses reduce waste.

cinquain - A form of poetry with five lines.

clarity - Clearness.

Clean Air Act - Originally passed in 1963 and amended in 1970 and 1990 to give the United States Environmental Protection Agency (U.S. EPA) the responsibility of setting air quality standards for each pollutant.

cloud - A visible mass of very fine droplets of water or particles of ice in the atmosphere above the Earth's surface.

code - A system of symbols given certain meanings, such as the numbering codes given to plastic packages to indicate the material type.

combustion - Burning of waste materials, fuels, etc.

commercial waste - Waste material that originates in wholesale business establishments such as office buildings or stores.

commingled materials - A mixture of several recyclables in one container.

compost - The product resulting from the decomposition of organic materials such as yard waste. Compost can be used as a soil conditioner.

composting - The conversion of organic materials to humus by microorganisms; an effective solid waste management method for reducing the organic portion of waste, including lawn clippings, leaves, kitchen scraps, and manure.

compost pile - A place, such as an outside pit or bin, set aside for composting waste.

Comprehensive Environmental Response, Liability and Compensation Act (CERLCA) - Passed by Congress in 1980 and usually referred to as Superfund, a fund to help pay for the management and cleanup of hazardous waste sites.

concentration - In chemistry, the amount of a specified substance in a unit amount of another substance.

condensation - The process by which a substance changes from its gaseous state to its liquid state.

conservation - The planned management of natural resources to prevent loss, destruction or waste.

consumer - A person who buys goods or services.

consuming/consumption - Buying and using goods or services.

contamination - The process of making the original substance impure or unusable.

contaminants - Compounds that pollute, making the original substance impure or unusable.

corrosive - In hazardous waste labeling, corrosive means that a product may eat through other items, such as its container.

corrugated paper - Paper or cardboard manufactured in a series of wrinkles or folds or into alternating ridges and grooves.

cover material - The soil used to cover solid waste in a landfill.

cradle to grave - In solid waste management, a look at a product from raw materials through manufacturing, use, consumption, and disposal.

cullet - Clean, generally color-sorted crushed glass used to make glass products.

cumulus - A type of cloud that is fluffy and flat based.

curbside recycling program - A program where recyclable materials are collected at our homes. The materials often are left in special containers on the curbside to be picked up by a recycling truck.

cycle - A repeated event or sequence of events.

danger - In household hazardous wastes labeling, danger means that exposure or unsafe use may cause injury, illness or death.

database - A collection of data or information arranged for computer access.

decompose - To break down into component parts or basic elements; decomposition of organic waste materials by bacteria is an essential life process because it makes essential nutrients available for use by plants and animals.

degradable - Can be decomposed, or broken down, such as yard wastes in a compost pile.

demolition debris - Waste materials produced during construction or remodeling including items such as used lumber, masonry, sheetrock, shingles, insulation, etc.

deinking - A process by which most of the ink, filler and other materials are removed from waste paper before using it to manufacture new paper.

de-tinning - A process by which the thin tin coating is removed and recovered from steel cans.

dewater - To remove the water from waste.

DHEC - The S.C. Department of Health and Environmental Control. DHEC was created in 1973 when the State Board of Health and the Pollution Control Authority merged. DHEC is responsible for protecting the state's environment and the health of South Carolinians.

diamante - A form of poetry shaped in the form of a diamond.

dilute - To make thinner or weaker as by mixing or dispersing.

disinfection - The process of treating water with chemicals or other means to kill microorganisms.

distillates - The liquid condensed from vapor in distillation.

distribution system - A series of pipes that carry clean drinking water from the water treatment plant to individual homes, schools, and businesses.

diversion rate - A measure of the amount of waste being diverted from the municipal solid waste stream either through recycling or composting.

do-it-yourselfer - A term for people who choose to change their own motor oil. These people are the focus of campaigns to get people to recycle their used motor oil.

DOT - Federal Department of Transportation.

drinking water - The water resources considered available and drinkable.

drop-off center - A designated site in the community where individuals may bring recyclables.

dump - An open, unmanaged, illegal disposal site used instead of sanitary landfills.

dumpster - A large container to keep waste until it is collected by the trash hauler. Dumpsters often are used by stores, apartment buildings and restaurants.

Earth Day - Held on April 22 each year to promote awareness of environmental issues, the first Earth Day was in 1970.

ecology - The scientific study of the relations of living things to one another and to their environment.

ecosystem - A system made up of a community of living things and the physical and chemical environment in which they interact.

editorial - An article published expressing the opinions of its editors or publishers.

effluent - Solid, liquid or gas waste that can enter the environment as a by-product of a chemical or biological process.

embedded energy - The total amount of energy an item uses during its lifetime.

emission - Substances that are given off or released from other processes, such as air pollution emissions.

end users - A business or manufacturer that takes recyclable materials and converts them into new products.

energy - The ability or capacity for doing work by a body or a system. A measure of the total heat in a system. Heat can be converted between a number of forms – light, motion, electricity, and warmth.

energy recovery - Recovering energy from waste. Used to describe recycling used oil into fuel that is burned to generate heat that produces electricity.

entropy - A measure of the capacity of a system to undergo spontaneous change.

environment - All the conditions, circumstances, and influences surrounding and affecting the development or existence of people or other living things.

EPA - The U.S. Environmental Protection Agency. It is the agency of the U.S. government that sets environmental protection and enforcement standards. The EPA was created in 1970 and serves the entire country through its 10 regional offices. South Carolina is in Region IV. The agency's headquarters is in Washington, D.C.

erosion - The wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical and chemical forces.

estimate - to make a judgment, to evaluate.

evaporation - The process by which a substance changes from its liquid state to its gaseous state.

exponential function - In math, expressed in terms of a designated power.

Federal Trade Commission (FTC) - The federal agency that supervises and regulates business competition by investigating unfair or harmful trade practices, such as misrepresentation in advertising.

ferrous metals - Metals that are predominantly composed of iron.

fertilizer - A material such as compost or a chemical compound added to soil to increase its fertility.

filter - A porous substance through which a gas or liquid is passed in order to remove its contaminants.

finished water - Water that has been processed for drinking at a water treatment plant.

finite - Limited in number.

flammable - Capable of igniting easily and burning quickly.

floatation deinking - A process in paper recycling where the ink is floated off paper with water.

fly ash - Small particles of ash and soot which are collected by pollution control devices during the incineration of solid wastes.

fog - Water vapor that has condensed to fine droplets lying in cloud-like masses close to the ground.

food chain - A succession of organisms in a feeding chain in which food energy is transferred from one organism to another as each consumes a lower member and is, in turn, preyed upon by a higher member.

fossil fuel - A nonrenewable energy source such as coal, petroleum, and natural gas.

garbage - Another word for solid waste, particularly household waste.

gas - One of the states of matter in which a substance has no fixed form or volume and takes the shape of its container.

generation - The act or process of producing solid waste.

geology - The study of the earth.

glasphalt - A highway paving material in which recovered ground glass replaces some of the gravel in asphalt.

GOFER - Give Oil For Energy Recovery. Santee Cooper's used oil recycling program.

greenhouse effect - A term scientist use to describe the trapping of heat on the surface of the Earth by the atmosphere, which is a normal occurrence. This effect is magnified by certain greenhouse gases in the atmosphere – carbon dioxide, methane, nitrogen oxides, and chlorofluorocarbons.

Green Seal - One of the first companies in the United States to award an environmental seal to products that meet certain environmental requirements.

Grinding of the Greens - A statewide Christmas tree recycling project. Information may be obtained from South Carolina Clean & Beautiful. (803) 734-0141.

groundwater - Water beneath the earth's surface that moves between soil particles and rock; supplies wells and springs.

groundwater flow - The slow movement of groundwater.

habitat - Place where a plant or animal normally lives; part of an ecosystem.

haiku - A form of poetry consisting of three lines of five, seven, and five syllables each.

hazardous - Dangerous.

hazardous substance - Substances such as chemicals that, if used improperly, may be dangerous to human health and/or the environment.

hazardous waste - Waste that may pose a threat to human health or the environment. The disposal, transportation and handling of hazardous waste is regulated by federal law.

HDPE - High-density polyethylene, a plastic resin commonly used to make milk jugs, detergent containers and base cups for plastic soda bottles. The standard plastic code for HDPE is 2.

heavy metals - Natural elements such as lead, mercury, cadmium and nickel.

high grade waste paper - The most valuable waste paper in the marketplace. High grade waste paper can be substituted for virgin wood pulp in making paper. Examples include letterhead stationery and computer paper.

household hazardous waste - Waste found around the home, usually in small amounts, that can harm people or the environment. Examples of household hazardous waste include paint, pesticides, cleaning supplies and batteries. Household hazardous waste is not regulated as a hazardous waste by South Carolina law, and is considered part of the municipal solid waste stream. Because of the nature of household hazardous waste, it should be stored properly and disposed of separately from solid waste.

human-made - Made by people.

humus - Organic material consisting of decayed vegetable matter that provides nutrients for plants.

hydrology - The scientific study of the distribution, circulation, or properties of the waters of the earth.

ignitable - In hazardous waste labeling, ignitable means that products may catch fire easily.

incident light wave -

impervious - Incapable of being penetrated, as by water.

incineration - The burning of waste.

incinerator - The facility in which the burning of waste takes place, incinerators are federally regulated.

industrial scrap - Waste generated during manufacturing operations.

industrial waste - Waste that results from industrial processes, such as manufacturing.

infiltration - Passing or joining gradually.

ingestion - To take food in by swallowing.

inorganic - Things not made from plant, animal, or carbon compounds; most inorganic compounds are derived from mineral resources.

insulation - A material that prevents the passage of heat, electricity, or sound.

integrated waste management - The complementary use of a variety of practices to manage municipal solid waste safely and effectively. Integrated waste management techniques include source reduction, recycling, composting, incineration and landfilling.

joule - The International System unit of energy equal to the work done when a current of 1 ampere is passed through a resistance of 1 ohm for 1 second.

kilowatthour - A common unit of electric power consumption equal to 1,000 watts acting for one hour.

LDPE - Low density polyethylene, a plastic used in shopping bags and garbage bags. The standard plastic code for LDPE is 4.

lampoon - A satirical piece found in print.

landfill - A large outdoor site for the burial of solid waste.

landfilling - The disposal of solid waste at permitted facilities in a series of compacted layers on land with daily covering of the waste with soil. Fill areas are carefully prepared to prevent risk to public health and the environment.

large quantity generator - Industries or other concerns that generate more than 1,000 kilograms of hazardous waste per month.

leachate - Rain water or other liquid that has percolated through solid waste and has extracted possibly hazardous dissolved or suspended materials from it. Leachate must be collected and treated to prevent it from contaminating ground and surface water.

lead-acid battery - Any battery that consists of lead and sulfuric acid, has a capacity of six volts or more and is used as a power source.

life cycle analysis - A process that examines a product from raw materials, manufacturing, transportation, and disposal cycles of its life.

life cycle cost - The total cost of an item using the initial cost, expected lifetime, and cost of energy used during the item's life span.

limited supply - In terms of natural resources, resources that are not available in unrestricted amounts. In many areas even renewable resources are considered to be in limited supply.

litter - Waste materials thoughtlessly discarded in an inappropriate place; littering is against the law in South Carolina.

liquid - One of the states of matter in which the substance takes the form of its container, has the ability to flow and has a fixed volume.

mandated recycling - Programs that by law require certain recycling practices or results.

manifest - A detailed shipping form required for all hazardous waste shipments.

manual separation - Sorting recyclables from other waste by hand.

marine debris - Trash or litter in the water.

materials recovery facility (MRF, pronounced murf) - A facility processing collected recyclables for end users.

matter - Anything that takes up space and can be perceived by one of the senses.

mechanical separation - A process in which recyclables are separated by various machines using, for example, magnets or air.

meter - A device used for measurement.

methane gas - A colorless, odorless, flammable and explosive gas produced by decomposing garbage and other organic materials.

microorganisms - Animals or plants of microscopic size.

mixed paper - Waste paper of various kinds and quality. Examples include stationery, notepads, manila folders and envelopes.

mixed waste - Unsorted waste from businesses or homes.

monitor - To keep watch over or supervise.

mulch - A protective layer around plants to prevent evaporation.

municipal solid waste (MSW) - The combined residential and commercial solid waste generated in an area. MSW includes paper, cans, bottles, food scraps, yard waste and other items. Industrial process waste, agricultural waste, mining waste and sewage sludge are not MSW.

municipal solid waste landfill - Any sanitary landfill, publicly or privately owned, that receives household waste. The landfill may also receive other types of solid waste, including commercial waste, non-hazardous sludge and industrial solid waste.

NIMBY - An acronym for "Not in my back yard." An expression of opposition for the siting of a waste facility near or in a community.

natural recycling - A process by which organic material decomposes in nature, such as leaves decomposing in a forest.

natural resources - Valuable, naturally-occurring items such as plants, animals, minerals, water, and air which are used by people to help make things such as energy, food, clothes, buildings, etc.

nitrogen cycle - The continuous cyclic progression of chemical reactions in which atmospheric nitrogen is compounded, dissolved in rain, deposited in the soil, assimilated and metabolized by bacteria and plants, and returned to the atmosphere following decomposition.

newsprint - An inexpensive paper made from wood pulp or recycled paper used primarily for newspapers.

nonbiodegradable - Does not degrade or break down in a compost pile.

nonferrous metals - Metals such as aluminum, copper or brass that contain no iron.

nonhazardous - Not considered dangerous.

nonpoint source pollution - Contamination, water pollution, that comes from many diffuse sources rather than a specific point such as a factory discharge pipe.

nonrecyclable - Cannot be recycled.

nonrenewable resources - Natural resources which, because of their scarcity, the length of time required to form them, or their rapid depletion, are considered finite in amount, such as petroleum, coal, natural gas, and copper.

observation - The noting and recording of facts and events.

Office of Solid Waste Reduction and Recycling - An office established by the S.C. Solid Waste Policy and Management Act of 1991. The office is part of DHEC's Division of Solid Waste Management and is non-regulatory and non-enforcement. It is responsible for public awareness and education campaigns dealing with solid waste and recycling issues, including curriculum development, landfill operator training, recycling demonstration projects and the management of several grant programs.

on-line networks - Computer-based information services that provide immediate access to data.

organic - Made from living organisms.

organic waste - Discarded living material such as yard and food waste.

ozone - A principal component of smog. Ground level ozone is harmful and causes health effects similar to asthma, and is known to harm trees and plants. However, an ozone layer that exists naturally in the stratosphere keeps out most of the dangerous ultraviolet rays from the sun that can cause skin cancer.

PET - Polyethylene terephthalate, a plastic commonly used to make soft drink bottles. The standard plastic code for PET is 1.

PP - Polypropylene plastic.

PS - Polystyrene plastic.

packaging - The wrapping, container or sealing used to protect, identify and advertise a product.

paperstock - Waste paper that has been sorted at the source into different grades.

particulate matter - Very small, separate particles, such as a particle of dust or fiber.

parts per billion - A proportion in which one unit per billion is measured.

parts per million - A proportion in which one unit per million is measured.

percolate - To pass or ooze through, as liquid percolates through a landfill.

permeable - Capable of being passed through such as soil which is permeable by water.

pervious - Open to passage, permeable.

pesticide - Any substance designed to kill living organisms, including insects (insecticides), plants (herbicides), fungi (fungicides), rats and mice (rodenticides), and bacteria (germicides).

petroleum - A natural, flammable liquid hydrocarbon mixture found principally beneath the earth's surface and processed to make gasoline, natural gas, naphtha, fuel, and lubricating oils. Also called crude oil.

pH - A numerical measure of the acidity of a substance, ranging from very low pH values such as 3 (vinegar) through neutral (7) to high values like 10 (lye).

photochemical reaction - A chemical reaction in the atmosphere that is triggered by sunlight. Pollutants often are created by photochemical reactions.

photosynthesis - Radiant energy from the sun is captured by green plants and converted into chemical energy during photosynthesis. Photosynthesis uses carbon dioxide and water and releases oxygen.

plankton - Plant and animal organisms, generally microscopic, that float and/or drift in great numbers in fresh or salt water.

planned obsolescence - Designed to be useful for a specific period of time, such as paper plates and cups which are designed to be used and throw away.

plastic - A man-made material made from hydrocarbons known for its light weight and durability.

poison - A substance that, through its chemical action, usually kills, injures or impairs a living thing.

political cartoon - Cartoon illustrations created to make a statement about politics.

pollution - Harmful substances deposited in the air, water, or on land, leading to contamination of the environment

polyethylene - A common plastic used to make plastic bags (LDPE standard plastic code 4) and milk bottles (HDPE standard plastic code 2).

polypropylene - A common plastic used to make deli tubs and straws (PP standard plastic code 5).

polystyrene - A lightweight plastic material often used in food service. Polystyrene products include trays, plates, bowls, cups and hinged containers (PS standard plastic code 6).

pore space - Tiny spaces between each grain of soil, sediment or within rock that can be filled by air or water.

post-consumer materials - Recovered materials that have been used by consumers.

precipitation - Water that falls as rain or snow.

pre-consumer materials - Recovered materials obtained from manufacturers, such as cutting scraps from printers

precycle - To reduce waste at the source by changing buying habits.

primary materials - Virgin or new materials, such as wood pulp and iron ore, used in making products.

profit margin - The margin or portion of the price paid for a product that is in excess of the company's expenses.

public service announcement - A commercial message broadcast for public good at no cost.

pulp - A soft, moist, sticky mass of fibers made up of wood, straw, etc., and used to make paper and paperboard.

pyrolysis - A chemical change caused by an increase in temperature.

RCRA - An acronym for Resource Conservation and Recovery Act.

rain - Water that condenses from atmospheric vapor and falls to earth as drops.

reactive - In hazardous waste labeling, reactive means that a product may explode.

recharge - To fill, as water seeps into the ground to fill aquifers and groundwater supplies.

recyclable - Products or materials that can be collected, separated and processed to be used as raw materials in the manufacture of new products.

recycle - To collect, separate, process and market materials so they can be used again.

recycled content - The amount of a product's weight or package's weight that is composed of materials that have been recovered from waste. Recycled content may include pre-consumer and post-consumer materials.

reduce - To lessen in amount. Reducing trash is a major solid waste management goal.

refurbish - Repair and make useful.

refuse - A general term for solid waste materials, also called garbage or trash.

renewable resource - A natural resource derived from an endless or cyclical source (e.g., sun, wind, trees, fish); with proper management and wise use, replacement of these resources by natural or human-assisted systems can be approximately equal to their consumption.

reprocessing - To process again. Re-refining used oil into new oil is a form of reprocessing.

re-refining - To refine again. Used oil that is reprocessed into new oil products is considered re-refined.

reservoir - A body of water stored for future use.

residue - The remainder of something after the removal of part.

resin - In plastics manufacturing, the different compounds used to create the different forms of plastic.

resource - A supply of something that can be used or drawn upon; something that can be used to make something else-wood into paper, bauxite ore into aluminum, old bottles into new ones, sand into glass, etc.

Resource Conservation and Recovery Act (RCRA) - Passed in 1976 to direct the Environmental Protection Agency to get involved in preventing industrial hazardous waste problems.

resource recovery - Use of high technology to burn mixed solid waste and produce energy; may involve mechanical separation of recyclables.

reuse - The use of a product more than once for any purpose.

runoff - Precipitation that hits the ground and runs down streets or over land

Safe Drinking Water Act - A rule originally passed by Congress in 1974. Its purpose is to make sure that drinking water supplied to the public is clean and safe. The Environmental Protection Agency sets the national drinking water standards and grant those states that meet certain criteria the task of managing their own public drinking water.

salt water intrusion - A process whereby salt water enters an area that once contained only groundwater.

SARA Title III - An acronym for Superfund Amendments and Reauthorization Act, which requires the release of information regarding toxic chemicals.

sanitary landfill - See municipal solid waste landfill.

scrap - Waste with some value, particularly material left over from construction or manufacturing suitable for reprocessing.

secchi disk - A device used to test the clarity of water.

secondary materials - Used materials, such as waste paper or scrap metal, handled by dealers and brokers.

sediments - Soil particles carried into water bodies.

septic tank - A tank into which sewage is discharged and decomposed by bacteria.

sewage - Mostly liquid waste, including human waste, which is transported away by sewers and purified in a sewage treatment plant.

sewage sludge - The muddy sediment left after sewage has been processed.

sewer system - Pipes that carry sewage away from homes to sewage treatment plants.

short-term impact - Immediate circumstances.

sinkhole - A natural depression of land formed by collapse of an underlying cavern roof.

small quantity generator - A small business, school, hospital or other concern that generates less than 1,000 kilograms of hazardous waste per month.

smog - A mixture of pollutants, principally ground-level ozone, produced by chemical reactions in the air of smog-forming chemicals. Smog can harm health, damage the environment, and cause poor visibility.

soil - The top layer of the earth's surface.

solid - Any substance that cannot flow, takes up space and has a definite shape and volume.

solid waste - Trash and garbage. In the S.C. Solid Waste Policy and Management Act of 1991, solid waste is defined as any garbage, refuse, or sludge from a waste treatment facility, water supply plant, or air pollution control facility; and other discarded material. It also includes solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining and agricultural operations and community activities.

Solid Waste Disposal Act - A federal law passed in 1965 and amended in 1970 that addressed waste disposal methods, waste management, and resource recovery.

solid waste management - The handling, processing and disposal of all solid waste.

solid waste stream - What we throw away.

soot - A fine, black powder formed by combustion or separated from fuel during combustion.

source reduction - Behavior to deliberately reduce waste through educated consumer choices and disposal.

source separation - Separating recyclable materials at the source, such as at home or office.

source water - Untreated water from a river, stream, lake or groundwater that is used to produce clean drinking water.

South Carolina Clean & Beautiful - A statewide educational program with local Keep America Beautiful affiliates conducting a variety of projects including the Adopt A Highway Program, Carolina Spring Clean, Take Pride in Public Lands, and Grinding of the Greens.

South Carolina Recycling Association - A non-profit organization established to promote recycling through education. The SCRA, based in Columbia, S.C., publishes a newsletter, has a resource library and sponsors workshops, conferences and seminars throughout the year across the state.

South Carolina Solid Waste Policy and Management Act of 1991 - The first comprehensive law dealing with solid waste management in South Carolina. The law establishes a policy of promoting solid waste reduction, recycling and reuse of materials before landfilling or incineration. It sets a goal of reducing the amount of solid waste being received at municipal solid waste landfills and incinerators by 30 percent, calculated by weight, by May 1997. It also sets a goal of recycling 25 percent, calculated by weight, of the total waste stream by May 1997. The bill was signed into law by Governor Carroll A. Campbell on May 27, 1991.

South Carolina Used Oil Partnership - A public-private partnership formed in May 1992 to increase public awareness about the importance of proper disposal of used oil. The partnership consists of DHEC's Office of Solid Waste Reduction and Recycling, Santee Cooper, the S.C. Department of Transportation and the S.C. Petroleum Council.

stagnant - Not moving or flowing, motionless.

states of matter - Three different forms (solid, liquid, and gas) in which one substance can occur dependent upon temperature.

static - In the term static use, use that stays at the same level and does not increase.

storm drains - Gutters and underground pipes that carry storm and runoff water away from streets.

Subtitle D - The solid, nonhazardous waste section of the Resource Conservation and Recovery Act (RCRA). Subtitle D provides specific information about landfill design, operation and closure.

Superfund - A large federal trust fund for cleaning up hazardous waste sites considered dangerous. Part of CERCLA.

surface area - A measurement of a rectangle or square that equals the length multiplied by the width.

surface water - Surface waters include streams, rivers, ponds, lakes, and manmade reservoirs. All fresh water that is not absorbed into the earth (becoming groundwater) or returned to the atmosphere as part of the water cycle is considered surface water. Only about .02 percent of all water on Earth is surface (fresh) water.

sustainable development - An environmental protection strategy designed to protect the earth's resources.

temperature - The degree of hotness or coldness of an object (a measure of energy).

TSDs - An acronym for treatment, storage and disposal facilities. These are facilities that are permitted to handle hazardous wastes.

thermodynamics - The physics of the relationships (dynamics) between heat (thermo) and other forms of energy.

throwaway life style - A phrase describing modern life with many disposable products and short-lived goods.

tipping fee - The price individuals, communities and trash haulers pay to dispose of their waste at a landfill.

topographic maps - Maps that show the physical features of a region.

topography - Detailed description or representation of the physical features of the region.

toxic - Poisonous.

toxicity - The degree of danger posed by a toxic or poisonous substance to animal or plant life.

trash - Material considered worthless, unnecessary, or offensive that is usually thrown away.

transfer station - A facility where waste is removed from small collection vehicles and loaded onto larger transport vehicles.

transpiration - To give off water vapor containing waste products.

turbidity - A measure of the amount of material suspended in water.

UBC - An acronym for Used Beverage Container, usually plastic soda bottles and aluminum cans.

used motor oil - Motor oil that has been used in an engine and is considered to be waste. Today this oil can be recycled.

vapor - A substance in the gaseous state that is ordinarily a liquid or solid.

V - Vinyl plastic.

Vinyl plastic - A common type of plastic used to make shampoo bottles and other containers (V standard plastic code 3).

virgin materials - Any basic material for industrial processes that has not previously been used. Examples include timber or metal ore.

volume - The amount of space an object can occupy. Solid waste may be measured by weight or volume.

warning - In household hazardous products labeling, warning means a stronger risk than caution, use with added care.

waste - Anything which is discarded or not considered useful.

waste audit - An inventory of the amount and type of solid waste that is produced at a specific location.

waste exchange - A program that helps companies offer some of their hazardous waste byproducts to other companies that may be able to use these wastes in their business.

waste reduction - An important waste management strategy that encourages people to generate less trash by watching what they buy.

waste stream - All the waste generated in an area or a facility.

waste-to-energy plants - Facilities that burn solid waste to produce energy.

wastewater - Water that has been used, either to manufacture a product or in the home, and which requires treatment and purification before it can be used again.

water - A molecule containing one oxygen and two hydrogen atoms.

water cycle - A series of naturally occurring events in which water is changed from a liquid to a gas (evaporation), rises into the atmosphere above Earth, is condensed into a form of precipitation and falls back to Earth some of which soaks down below the Earth's surface into the groundwater. The water cycle also includes transpiration of water by plant life.

water meter - A device which measures the amount of water flow.

Water Pollution Control Act - Passed in 1972 to allow the Environmental Protection Agency to set water quality standards and regulate water pollution.

watershed - The geographic region within which water drains into a particular body of water.

water table - The depth or level below which the ground is saturated with water.

water treatment plant - A facility where source water is cleaned and disinfected to meet Federal Safe Drinking Water standards.

water vapor - Water in its gaseous state.

waterways - Navigatable bodies of water, as a river.

well - A deep hole dug down in the ground to obtain water or other substances.

white goods - Appliances such as refrigerators, stoves, water heaters, washing machines, dryers and air conditioners.

yard waste - Grass clippings, shrub prunings, leaves, tree branches and other discarded material from yards and gardens.

BOOKS, VIDEOS, AND OTHER INFORMATION

The South Carolina Department of Health and Environmental Control's Office of Solid Waste Reduction and Recycling has a Resource Center in Columbia. This center has videos, books, and current information on many environmental topics.

The Resource Center is staffed by a librarian who can assist you and your students with research on a variety of topics related to solid waste and environmental conservation. Students are welcome to conduct their research in-person or may request that the research be conducted for them. Materials will be mailed as available.

To reserve materials for use in your classroom, please call, 1-800-768-7348, or write to the Department of Health and Environmental Control, Resource Center of the Office of Solid Waste Reduction and Recycling, 2600 Bull Street, Columbia, South Carolina 29201. We're here to help.

Some of the resources that may be accessed include:

Directories

- The American Recycling Markets Guide
- The Recycled Products Guide
- South Carolina Recycles: a directory of recycling programs and markets
- Index of Waste Minimization Resources for South Carolina Industries
- South Carolina Industrial Directory
- Access EPA: a directory of U.S. EPA and other public sector environmental resources

Topical Files

These files include information collected from a variety of sources, filed alphabetically by topic, including fact sheets, case studies, journal articles, promotional materials, reports and vendor information. Topics include batteries, composting, landfills, paper, recycling markets, plastics, metals, glass, recycling programs, incineration, tires, and white goods (appliances).

Journal Index

This is an electronic index of solid waste and recycling journals. The index is searched by topic and provides a citation including the title of the article, the name of the journal, and when it appeared. The journals themselves are housed in the Resource Center in Columbia. Journals indexed include:

- | | |
|--------------------------------------|---|
| • <i>American City and County</i> | • <i>Resource Recycling</i> |
| • <i>Biocycle</i> | • <i>Reusable News</i> |
| • <i>Bottle/Can Update</i> | • <i>Solid Waste Technologies</i> |
| • <i>Environmental Headline News</i> | • <i>Solid Waste Digest</i> |
| • <i>MSW Management</i> | • <i>Solid Waste Report</i> |
| • <i>Pollution Prevention News</i> | • <i>Steel Can Recycling Newsletter</i> |
| • <i>Recycling Times</i> | • <i>Waste Age</i> |
| • <i>Recycling Today</i> | • <i>World Wastes</i> |

Books

These resources may be checked out upon request. Available are a variety of titles including elementary fiction, environmental reference, and activity books. Please call for information, as new titles are being added all the time.

Videos

Videos may be checked out as needed. Topics include recycling, used oil, over population, and air quality.

In-House Publications

The Resource makes available in quantities brochures and fact sheets published by the Office of Solid Waste Reduction and Recycling. These are generally South Carolina specific. Topics include recycling, composting, used oil recycling, scrap tire recycling, buying recycled, and fun recycling facts.

U.S. EPA Publications

Many U.S. EPA documents related to recycling, solid waste, and environmental protection are available in the Resource Center.

On-Line Resources

A variety of on-line services may be searched in the Resource Center. These include Solid Waste Information Clearinghouse, Eco-Net, Recycleline, the Pollution Prevention Information Clearinghouse, and Environet.

Regulatory Documents

Copies of South Carolina Environmental Regulations are available from the Resource Center.

In addition to the Resource Center of the Office of Solid Waste Reduction and Recycling, other Department of Health and Environmental Control Bureau's can provide educational support.

For additional information on air quality, please contact Susan Provence, Bureau of Air Quality, SC DHEC, 2600 Bull Street, Columbia, SC 29201. (803) 734-2862.

For additional information on water pollution, please contact Beth Miller, Bureau of Water Pollution Control, SC DHEC, 2600 Bull Street, Columbia, SC 29201. (803) 734-0866.

For additional information on drinking water, please contact Janet Clarke, Bureau of Drinking Water Protection, SC DHEC, 2600 Bull Street, Columbia, SC 29201. (803) 734-6097.

Read More About It ...

Several of these books are available in the Resource Center. Other titles may be available in your local library or book store.

The 1993 Information Please Environmental Almanac, World Resources Institute, Houghton Mifflin.

The 1994 Information Please Environmental Almanac, World Resources Institute, Houghton Mifflin.

Environmental Literacy: The A to Z Guide, Steven Dashefsky, Random House.

1993 Earth Journal, editors of *Buzzworm* magazine, Buzzworm Books.

Earth in the Balance: Ecology and the Human Spirit, Vice President Al Gore, Houghton Mifflin.

The Rolling Stone Environmental Reader, the editors of Rolling Stone magazine, Island Press.

State of the World 1992, Lester Brown, W.W. Norton, New York. (Annual Worldwatch Institute report)

Rubbish!: The Archaeology of Garbage, William Rathje and Cullen Murphy, HarperCollins, New York.

The Garbage Primer A Handbook for Citizens, The League of Women Voters, Lyons & Burford, New York.

The Directory of National Environmental Organizations, John C. Brainard and Roger N. McGrath, St. Paul.

The Encyclopedia of Environmental Studies, William Ashworth, Facts On File, New York.

EcoLinking – Everyone's Guide to Online Environmental Information, Don Ritter, Peachpit Press, Berkeley.

Environmental Success Index 1992, Renew America, Washington, DC.

The Green Encyclopedia, Irene Franck and David Brownstone, Prentice Hall General Reference, New York.

World Resources 1992 -1993, The World Resources Institute, The United Nations Environment Programme and the United Nations Development Programme, Oxford University Press, New York.

Recycle!: A Handbook for Kids, Gail Gibson, Little, Brown and Co.

A River Ran Wild, Lynne Cherry, Harcourt Brace Jovanovich, New York.

Just A Dream, Chris Van Allsburg, Houghton Mifflin Books, Boston.

Taking Out The Trash, Island Press.

Save The Earth: Big Book of Questions and Answers, Linda Schwartz, Publications International.

Earth Child, Carol Haralson, Council Oak Books, Tulsa.

The Great Kapok Tree: A Tale of the Amazon Rain Forest, Lynne Cherry, Harcourt Brace Jovanovich, New York.

The Mountain, Peter Parnall, Doubleday and Co., New York.

The Lost Lake, Allen Say, Houghton Mifflin, Boston.

Bangalee, Stephen Cosgrove.

Where Does the Garbage Go?, Paul Showers, Crowell.

Dear Garbage Man, Gene Zion, Harper & Row.

Heloise: Tips for a Healthy Planet.

Our Dirty Land, Sarah Elliott, Messner.

Recycling: Reusing Our World's Solid Waste, James Hahn.

Energy: The New Look, Margaret O. Hyde, McGraw-Hill.

Waste Technology, Ann Zane Shanks, Viking.

Going Green, John Elkington, Julia Hailes, Douglas Hill, and Joel Makower, Puffin Books.

The Kids Nature Book: 365 Indoor/Outdoor Activities, Susan Milord, Williamson Publishing.

50 Simple Things Kids Can Do to Save the Earth, The Earth Works Group, Earthworks Press.

The Next Step: 50 More Things Kids Can Do to Save the Earth, The Earth Works Group, Earthworks Press.

The Student Environmental Action Guide, The Earth Works Group, Earthworks Press.

The Lorax, Dr. Seus, Random House.

The Planet of Trash: An Environmental Fable, George Poppel, National Press.

The Wump World, Bill Peet, Houghton Mifflin.

The Green Consumer, Joel Makower, Penguin Books.

Backyard Composting, Harmonious Technologies, Harmonious Press.

Worms Eat My Garbage, Mary Appelhof, Flower Press.

Antarctica, The Last Unspoiled Continent, Laurence Pringle, Simon and Shuster, New York.

Likeable Recyclables, Creative Ideas for Reusing Bags, Boxes, Cans, and Cartons, Linda Schwartz, Learning Works, Santa Barbara.

Energy Projects for Young Scientists, National Energy Foundation, Robert Gardner, Franklin Watts.

Energy for Tomorrow's World, World Energy Council, St. Martin's Press.

Atoms To Electricity, U.S. Department of Energy, Assistant Secretary for Nuclear Energy, Office of Support Programs. DOE/NE-0085 November 1987.

Conservation II - Science Activities in Energy, with teachers guide, Prepared by Oak Ridge Associated Laboratories, Oak Ridge, TN. Prepared for the U.S. Department of Energy, Office of Energy Research, Washington, D.C. 20585.

Solar Energy - Science Activities in Energy, Prepared by Oak Ridge Associated Laboratories, Oak Ridge, TN. Prepared for the U.S. Department of Energy, Office of Energy Research, Washington, D.C. 20585.

Solar Energy II- Science Activities in Energy, Prepared by Oak Ridge Associated Laboratories, Oak Ridge, TN. Prepared for the U.S. Department of Energy, Office of Energy Research, Washington, D.C. 20585.

Solar Science Projects - Southface Energy Institute, Atlanta, GA.

Science Projects in Renewable Energy and Energy Efficiency, A Guide for Elementary and Secondary School Teachers, National Renewable Energy Laboratory, Golden, CO.

Teach With Energy, Fundamental Energy, Electricity and Science Lessons for Grades 4 - 6, The National Energy Foundation, Salt Lake, UT.

Teach With Energy, Fundamental Energy, Electricity and Science Lessons for Grades K-3, The National Energy Foundation, Salt Lake, UT.

Energy Glossary, The National Energy Foundation, Salt Lake, UT.

The Energy Book, The South Carolina Department of Education.

Quick Energy For Elementary Teachers, The National Energy Foundation, Salt Lake, UT.

Energy and Economics, The National Energy Foundation, Salt Lake, UT.

The Energy Factbook, A Resource for South Carolina, The South Carolina Energy Office, Columbia, SC, 1995.

Periodicals/Magazines

American Forests, published bimonthly by American Forests, P.O. Box 2000, Washington, D.C. 20013.

The Amicus Journal, The American Horticultural Society, 7931 E. Boulevard Dr. Alexandria, VA 22308.

Audubon, the National Audubon Society, 700 Broadway, New York, NY 10003.

Biocycle: Journal of Waste Recycling, J.G. Press, Inc., (215) 967-4135. \$55/year, 12 issues. A monthly journal specializing in organic composting, recycling, and reuse.

Buzzworm, Buzzworm, Inc., 2305 Canyon Blvd. Ste. 206, Boulder, CO 80302.

E: The Environmental Magazine, Earth Action Network, Inc., 28 Knight Street, Norwalk, CT 06851, (203) 854-5559. \$20/year, 6 issues. A bimonthly magazine covering a wide range of environmental issues with regular articles on solid waste management.

EPA Reusable News, Environmental Protection Agency, Office of Solid Waste and Emergency Response, 401 M Street, SW, Washington, DC 20460. A quarterly newsletter on U.S. EPA's efforts and others regarding municipal solid waste management.

EPA Used Oil Recycling, Environmental Protection Agency, Office of Solid Waste and Emergency Response, OS-323, 401 M Street SW, Washington, DC 20460. A quarterly newsletter covering local, state, and national news and developments regarding used oil recycling.

Garbage: The Practical Journal for the Environment, Old House Journal Corp., 435 9th Street, Brooklyn, NY 11215, (718) 788-1700. An environmental magazine covering topical recycling and waste management issues.

The Green Consumer Letter/The Green Business Letter, Tilden Press, 1526 Connecticut Ave., NW, Washington, DC 20036. Written by Joel Makower.

Household Hazardous Waste Management News, Waste Watch Center, 16 Haverhill Street, Andover, MA 01810, (508) 470-3044. Published quarterly; subscriptions are free. A newsletter focusing on regional, national, and international household hazardous waste management efforts.

Recycling Times, Waste Age's Recycling Times, 5615 W. Cermak Road, Cierco, IL 60650. \$95/year, 26 issues. A biweekly newspaper on recycling markets published by the National Solid Waste Management Association.

Recycling World, Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010. Published irregularly; single copy free with stamped, self-addressed envelope. A newsletter promoting practical action for the environment.

Sierra, Sierra Club, 730 Polk Street, San Francisco, CA 94109.

Solid Waste & Power: The Magazine of Waste Management Solutions, (816) 931-1311. \$49/year, 7 issues. A bimonthly magazine aimed at waste-to-energy systems and recycling.

Waste Age, 1730 Rhode Island Avenue, Suite 1000, NW, Washington, DC 20036, (202) 861-0708. \$45/year, 12 issues. A monthly magazine focusing on the industry and technology of waste systems.

WorldWatch, WorldWatch Institute, 1776 Massachusetts Ave., NW, Washington, DC 20036.

Resources on Video, Slides and Tape...

To reserve videos for use in your classroom, please call, 1 800 768 7348. We're here to help.

THE ROTTEN TRUTH

30 Minutes

All ages

Produced by Children's Television Network. Looks at the amount of garbage we produce, and how it is landfilled, combusted, or recycled. This video is designed for middle school students, but is entertaining enough for anyone from older elementary students to adults.

HERE TODAY, HERE TOMORROW

15 Minutes

Grades 1 to 4

Set in the future, this video looks at the amount of garbage produced, and how we are running out of landfill space. Produced by the Aid Association for Lutherans.

WORKING TOGETHER FOR A HEALTHIER PLANET

15 Minutes

Middle School to Adults

Produced by The Society of the Plastics Industry. Looks at the composition of the waste stream. Addresses some concerns about plastics disposal and recycling.

RECYCLE THIS! ROCK 'N ROLL AND RECYCLING

40 Minutes

Middle School

Entertainment style, song and dance. This lively video looks at landfill problems and what can be recycled.

A POPULAR LITTLE PLANET

30 Minutes

Produced by 3-2-1 Contact. See the effect of population growth on our environment.

GET BUSY: HOW KIDS CAN SAVE THE PLANET

30 Minutes

Produced by 3-2-1 Contact. Explore the positive and negative effects of modern technology and see kids who are making important efforts.

YOUR TOXIC TRASH

30 Minutes

Middle and High School

Produced by KERA-TV in Dallas/Ft. Worth. Ed Begley, Jr. looks at household hazardous material in your home.

BOTTOM OF THE BARREL

30 Minutes

Elementary and Middle School

Produced by the Children's Television Network and available through 3-2-1 Contact. This video looks at the many uses of oil in our society and the environmental concerns.

Videos from other Sources

YAKETY YAK – TAKE IT BACK

45 Minutes

Elementary and Middle School

Promotes the 3R's message through short skits using animation and celebrities.

DOWN THE DRAIN

30 Minutes

Elementary and Middle School

Produced by the Children's Television Network and available through 3-2-1 Contact. This video explores drinking water and how the water you drink today is the same water dinosaurs drank. Explores the water cycle and water conservation and preservation.

YOU CAN'T GROW HOME AGAIN

60 Minutes

Elementary and Middle School

Produced by the Children's Television Network and available through Contact. This video looks at what's being done to save rainforests and their inhabitants.

TOMORROW'S ENERGY TODAY & TOMORROW'S ENERGY TODAY: THE ENERGY EFFICIENT OPTION

23 Minutes and 26 Minutes

Middle School and High School

Produced by the Children's Television Network and available through Contact. This video looks at what's being done to save rainforests and their inhabitants.

The following videos are available through South Carolina Clean & Beautiful

For more information on resources available from the organization, write or call 1205 Pendleton Street, Suite 517, Columbia, South Carolina 29201, 803 734-0141.

CLEAN GETAWAY

20 Minutes

An original musical comedy featuring a cast of five characters; Detective Curbside, his sidekick Sam, Coffee Man, Convenience Lady, and the Chip Kid. The audience gets to act as jury in deciding the trios innocence or guilt. Offers recycling, waste reduction, and reuse options.

GONE WITH THE WASTE

16:32 Minutes

From the U.S. Environmental Protection Agency. Emphasizes the importance of the South's natural resources and the threat of the growing amount of trash. Explains the EPA's solution to the solid waste problem through source reduction, combustion, recycling, and landfilling.

HOW DID THIS GET HERE?

9:22 Minutes

From Keep America Beautiful, Inc. and RJR Nabisco. Gives brief overview of solid waste and litter problems and then examines where litter originates. Also examines the role of Keep America Beautiful in stopping the litter problem.

KEEP IT CLEAN

18:17 Minutes

From the Garden Club of Georgia. Sonny Shroyer takes his young friends on a nature club field trip during which they discover Woodsy the Owl making a video of trash located in the woods. Emphasis is placed on the need to care for our natural resources. Sonny and his friends continue their walk and discover Smokey the Bear who presents the fact that misplaced waste is dangerous and can cause fires. After their visit with Smokey, they meet a magician who turns trash into cash. Recycling of aluminum, glass, paper, and magazines is discussed. Advantages of recycling and guidelines for recycling are also discussed. Note: "Trash into Cash" is not always an option for individuals or communities.

OVERVIEW: SOLID WASTE DISPOSAL ALTERNATIVES

25 Minutes

From Keep America Beautiful, Inc. Explores the solid waste problem and its alternatives, by discussing land filling, waste-to-energy, composting, source reduction, recycling, and composting.

RUDY MANCKE - ETV NATURE SCENE: 11 Spots SC Governor's Task Force on Litter: 2 PSA's

41:45 Minutes

From SC Educational TV, Governor's Task Force on Litter for SC Clean & Beautiful. Naturalist Rudy Mancke visits locations dealing with the environment, litter enforcement, recycling, and natural resources. These spots include: visiting a landfill, man and nature as one (using a landfill), boating on lakes and the importance of not littering in the water, the mountains of SC and the importance of water resources, responsibility of controlling litter, natural areas and problems with litter. Also, protection of natural areas and the responsibility of citizens, the beaches of SC, the world of nature and its diversity, heritage of South Carolinians, and the world of nature and recycling. The ETV spots are followed by two Governor's Task Force on Litter PSA's that include: Nothing Could be Finer than a Cleaner Carolina public service announcement that shows wildlife in the woods, and a PSA that shows littering.

TAKE PRIDE IN AMERICA Release Tape

11:08 Minutes

Lois Gossett, Jr. explains the importance of being a "Good Guy" and preserving the earth's natural resources by taking responsibility and treating the land as if it truly belongs to us.

THIS WAS YOUR PLANET

7 Minutes

From Quality Forward, Keep America Beautiful System. A teenager dreams he is a contestant on a game show set in the future. Shows how the planet will be if he and his friends don't take steps to stop litter now.

MR. ROGERS - THE ENVIRONMENT AND RECYCLING

30 Minutes

From the Public Broadcasting System and Keep America Beautiful. Mr. Rogers visits a recycling center.

A USER'S GUIDE TO PLANET EARTH

30 Minutes

In this network television special, the viewer is challenged to answer 20 environmental questions, then scored on his answers. Tom Selleck hosts, and questions are answered and explained by television and movie personalities such as Bette Midler, Candice Bergen, and Kermit and Miss Piggy.

GLASS: ALL NATURAL, ALL RECYCLABLE

9:26 Minutes

From Carolinas Glass Recycling Program. This tape describes how glass is made, its recyclability, the advantages of glass recycling, and attitudes toward glass containers. It states that the results of a survey indicate that glass recycling reduces litter, saves landfill space, conserves natural resources, conserves energy, and generates income.

HOW PAPER RECYCLING WORKS

12:45 Minutes

From the American Paper Institute. A step-by-step guide to the various types of paper recycling. Examines the collection methods, transportation and market possibilities of recycled paper.

THE LANDFILL STORY

17:24 Minutes

From Browning-Ferris Industries. Follow two reporters as they tour a local landfill and interview the landfill manager. The processes of selecting a landfill site, preparing it, and closing it are described in detail. Information on sanitary landfills is included.

LEARN AND EARN

5 Minutes

From Phoenix Recycling. Overview of Phoenix Recycling Inc.'s plastic bag recycling program available for schools.

ONE STOP SHOPPING, ONE STOP RECYCLING

6 Minutes

From the Glass Containers Industry. The advantages of one-stop curbside collection recycling programs are compared to the disadvantages of force deposit laws. One-stop collection, just like one-stop grocery store shopping, is seen as the solution of choice, simple and convenient.

PLASTICS RECYCLING TODAY: A GROWING RESOURCE

11:38 Minutes

From The Council for Solid Waste Solutions. Examines the plastics recycling industry by explaining what types can be recycled, how it is recycled, and how it is used.

RECYCLING: IT'S NATURE'S WAY

6:40 Minutes

From Alcoa Aluminum Recycling. Aluminum recycling from can to metal and back to can is discussed. The impact of recycling is shown by discussing the savings of energy and raw materials, the effect on the economy and the environment, the ability to make money through recycling, and the savings of natural resources. Reference is made to the Aluminum Cans for Burned Children Program.

THE RESOURCE REVOLUTION

12 Minutes

Grades 7-12

From The Council for Solid Waste Solutions. This film shows the gains in plastics recycling and the role recycling plays in dealing with our nation's garbage crisis. Includes teacher's guide that will help inspire students to get involved in recycling.

STEEL: AMERICA'S MOST RECYCLED MATERIAL

8 Minutes

From the Steel Can Recycling Institute. Discusses the heightened awareness of both government and public towards steel can recycling. Discusses the steel industries history of recycling and encourages an increase in recycling efforts. Also discusses the efforts of the Steel Can Recycling Institute to promote steel recycling in businesses and communities.

The following are available through Clemson University

For information on the many resources available from Clemson University, contact your local extension office.

AN R-DAY FOR YOUR COMMUNITY

10 minutes

How to develop and conduct an R-Day (recycling day). Advice from the Governor's Task Force on Litter and Keep America Beautiful.

DRINKING WATER: QUALITY ON TAP

27 minutes

General introduction to the issue of water quality and protection. 1992.

ENVIROSHOPPING

20 minutes (80 slides with script and tape)

Highlights concepts of reduce, reuse, recycle, reject, and respond as they relate to solid waste and targets decision making in the marketplace. 1992.

4-H WATER QUALITY

Four video tapes 10 minutes each

Topics are: ground water, saving water, surface water, and waste water treatment.

RECYCLE YARD WASTES BY COMPOSTING

64 color slides with script

Explains the composting process. 1991.

SOLID WASTE LEGISLATION FOR SOUTH CAROLINA

90 minutes

Examines the South Carolina Solid Waste Policy and Management Act. 1991.

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Other Sources of Information

For more information about solid waste, recycling, or the environment, there are a number of places teachers can contact for help.

Air and Waste Management Association, P.O. Box 2861, Pittsburg, PA 15230. (412) 232-3444.

Aluminum Association, 900-19th St. N.W., Washington, D.C. 20006. (202) 862-5100.

Aluminum Recycling Association, 1000 16th St. N.W., Suite 603, Washington, D.C. 20036. (202) 785-0951.

American Forest and Paper Institute, 260 Madison Ave., New York, N.Y. 10016. (212) 340-0654.

American Iron and Steel Institute, 11-1 - 17th St. N.W., Ste. 1300, Washington, D.C. 20005. (202) 452-7100.

American Petroleum Institute, 1220 "L" St. N.W., Washington, D.C. 20005. (202) 682-8230.

American Plastics Council, 1275 "K" St. N.W., Ste. 400, Washington, D.C. 20005. (202) 371-5319, (800) 2-HELP90.

American Retreaders Association, P.O. Box 37203, Louisville, KY 40233-7203. (502) 968-8900.

America's Clean Water Foundation, 444 North Capitol Street, NW, Suite 330, Washington, D.C. 20001. (202) 624-7833.

Composting Council, 114 S. Pitt St., Alexandria, VA 22314. (703) 739-2401.

Council for Solid Waste Solutions, 1275 K St. N.W., Washington, D.C. 20005. (202) 371-5319.
Affiliate of The Society of the Plastics Industry, same address. (202) 371-5200.

Council on Packaging in the Environment, 1001 Connecticut Ave. N.W. Ste. 401, Washington, D.C. 20036-5504. (202) 331-0099.

Cousteau Society, 930 W. 21st Street, Norfolk, Virginia 23517. (804) 627-1144.

Energy Efficiency and Renewable Energy Clearinghouse, P.O. Box 3048, Merrifield, Va. 22116. (800) 363-3732.

Environmental Defense Fund, 257 Park Ave. South, New York, New York 10010. (212) 505-2100.

Environmental Protection Agency, 401 M. St., N.W., Washington, D.C. 20460. (202) 382-2080. To order U.S. EPA publications call the RCRA Hotline, (800) 424-9346.

Glass Packaging Institute, 1627 "K" St., Ste. 800, Washington, D.C. 20006. (202) 887-4850.

Hazardous Waste Management Association, 4301 Connecticut Ave. NW, Washington, D.C. 20008. (202) 244-4700.

INFORM, Inc. 381 Park Avenue South, New York, NY 10016, (212) 689-4040.

Institute of Scrap Recycling Industries, 1627 K St. N.W., Washington, D.C. 20006. (202) 466-4050.

Keep America Beautiful, 9 W. Broad Street, Stamford, CT 06902. (203) 323-8987.

Municipal Waste Management Association, 1620 "I" St. N.W., Washington, D.C. 20006. (202) 293-7330.

National Association for Plastic Container Recovery, P.O. Box 7784, Charlotte, N.C. 28241. (704) 358-8882.

National Association of Chemical Recyclers, 12 "G" St. N.W., Ste. 800, Washington, D.C. 20005. (202) 434-8740.

National Audubon Society, 950 Third Avenue, New York, New York, 10022. (212) 832-3200.

National Geographic Society, 17th and M Streets, NW, Washington, D.C. 20240.

National Oil Recyclers Association, c/o Thelen, Martin, Johnson & Bridges, 805 15th St. N.W. Suite 900, Washington, D.C. 20005. (202) 962-3000. Also, 12429 Cedar Rd. Ste. 26, Cleveland, OH 44106. (216) 791-7316.

National Recycling Coalition, 1101 30th St. N.W. Suite 305, Washington, D.C. 20007. (202) 625-6406.

National Soft Drink Association, Solid Waste Management Dept., 1103 16th St. N.W., Washington, D.C. 20036. (202) 463-6700.

National Solid Waste Institute, 10928 North 56th St., Tampa, Fla. 33617. (813) 985-3208.

National Solid Wastes Management Association, 1730 Rhode Island Ave. N.W. Suite 1000, Washington, D.C. 20036. (202) 659-4613.

National Tire Dealers and Retreaders Association, 1250 1 St. N.W., Suite 400, Washington, D.C. 20005. (202) 789-2300, (800) 87-NTDRA.

Plastics Institute of America, 227 Fairfield Rd., Ste. 307, Fairfield, NJ 07004-1932. (201) 808-5950.

Recycled Products Information Clearinghouse, 5528 Hempstead Way, Springfield, VA 22151. Provides recycled product and market information. (703) 941-4452.

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South Carolina Center for Waste Minimization, (803) 734-5360.

South Carolina Clean & Beautiful, 1205 Pendleton Street, Suite 517, Columbia, South Carolina 29201, (803) 734-0141.

South Carolina Department of Health and Environmental Control Office of Solid Waste Reduction and Recycling, 2600 Bull Street, Columbia, South Carolina, 29201 (800) 76 USE IT.

South Carolina Petroleum Council, 1340 Bull Street, Suite 250, Columbia, South Carolina 29201, (803) 799-9588.

South Carolina Recycling Association, P.O. Box 7464, Columbia, South Carolina 29202. (803) 252-9250.

South Carolina Wildlife Federation, 715 Woodrow Street, Columbia, South Carolina 29205. (803) 771-4417, FAX (803) 771-6120.

The Nature Conservancy, 1815 N. Lynn Street, Arlington, VA 22209. (703) 841-5300.

The Sierra Club, 730 Polk Street, San Francisco, CA 94109. (415) 776-2211.

United States Department of Energy, Washington, D.C. 20585. (202) 586-5000.

Superfund Hotline: (800) 424-9346. Provides information and compliance requirements.



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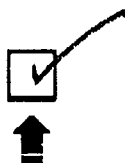
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